POLITECNICO SETUBAL

Novembro 2023
16 a 18

Atas SIIE23

XXV Simpósio Internacional de Informática Educativa

Atas do XXV Simpósio Internacional de Informática Educativa

FICHA TÉCNICA
Setúbal, Portugal
16, 17 e 18 de novembro de 2023
Instituto Politécnico de Setúbal

Editores
Maria do Rosário Rodrigues – Instituto Politécnico de Setúbal
Miguel Figueiredo – Instituto Politécnico de Setúbal
João Torres – Instituto Politécnico de Setúbal

Título: Atas do XXV Simpósio Internacional de Informática Educativa
Editor e Copyright Instituto Politécnico de Setúbal
Local: Setúbal, Portugal
Website: https://eventos.ese.ips.pt/siie2023/
ISBN: 978-989-35377-2-5
Ano: 2023
Nº de Páginas: 340

Steering Committee

Martín Llamas Nistal (Universidad de Vigo, Espanha) **Presidente**

António José Mendes (University of Coimbra, Portugal)

Ángel Velázquez Iturbide (Universidad Rey Juan Carlos, Espanha)

Cristina Azevedo Gomes (Escola Superior de Educação de Viseu – Instituto Politécnico de Viseu, Portugal)

Francisco José García-Peñalvo (Universidad de Salamanca, Espanha)

Comissão Científica

Maria do Rosário Rodrigues (Instituto Politécnico de Setúbal, Portugal) **Presidente**

Alicia García Holgado (Universidad de Salamanca, Espanha)

Ana A. Carvalho (University de Coimbra, Portugal)

Ana-Belén González Rogado (Universidad de Salamanca, Espanha)

Ana Cristina Loureiro – Instituto Politécnico de Santarém – Escola Superior de Educação de Santarém e LE@D – Laboratório de Educação a Distância e E-Learning

Ana Isabel Molina (Universidad de Castilla-La Mancha, Espanha)

Ana Rute Martins (Instituto Politécnico de Setúbal, Portugal)

Anabela Gomes (Instituto Politécnico de Coimbra, Portugal)

Antonio Balderas (University of Cádiz, Espanha)

Antonio Manso (Techn&Art, Portugal)

Antonio Sarasa Cabezuelo (Universidad Complutense de Madrid, Espanha)

António Mendes (University of Coimbra, Portugal)

António Moreira (Universidade de Aveiro, Portugal)

António Osório (University of Minho, Portugal)

Belmiro Rego (Escola Superior de Educação de Viseu – Instituto Politécnico de Viseu, Portugal)

Carina González González (Universidad de La Laguna, Espanha)

Célio Marques (Instituto Politécnico de Tomar, Portugal)

Covadonga Rodrigo (UNED – Universidad Nacional de Educación a Distancia, Espanha)

Cristian Cechinel (UFSC – Federal University of Pelotas, Brasil)

Cristina Azevedo Gomes (Escola Superior de Educação de Viseu – Instituto Politécnico de Viseu, Portugal)

Davinia Hernández Leo (Universitat Pompeu Fabra, Barcelona, Espanha)

Diana Perez-Martín (Universidad Rey Juan Carlos, Espanha)

Eduarda Ferreira (Interdisciplinary Centre of Social Sciences (CICS.NOVA), Faculty of Social Sciences and Humanities (FCSH/NOVA), Portugal)

Erla Morales (Universidad de Salamanca, Espanha)

Estefanía Martín Barroso (Universidad Rey Juan Carlos, Espanha)

Faraón Llorens Largo (Universidad de Alicante, Espanha)

Fernando Albuquerque Costa (Instituto de Educação – Universidade de Lisboa, Portugal)

Fernando Mikic (University of Vigo, Espanha)

Francisco José García Peñalvo (University of Salamanca, Espanha)

Gregorio Robles (Universidad Rey Juan Carlos, Espanha)

Henrique Gil (Age.Comm – Instituto Politécnico de Castelo Branco, Portugal)

Isabel Pereira (Instituto Politécnico de Leiria, Portugal)

João Vitor Torres (Instituto Politécnico de Setúbal, Portugal)

J. Ángel Velázquez-Iturbide (Universidad Rey Juan Carlos, Espanha)

Jaime Sánchez (Universidad de Chile, Chile)

Jaime Urquiza Fuentes (Universidade Rey Juan Carlos, Espanha)

José Luis Sierra Rodríguez (Universidad Complutense de Madrid, Espanha)

José-V. Benlloch-Dualde (Politècnica de València)

Juan Manuel Dodero Beardo (Universidad de Cádiz, Espanha)

Luis Anido Rifón (Universidad de Vigo, atlanTTic, Espanha)

Luis Pedro (University of Aveiro, Portugal)

Luís Valente (Universidade do Minho, Portugal)

Manuel Rodríguez (University of Vigo, Espanha)

Manuel Castro (Universidad Nacional de Educación a Distancia, Espanha)

Manuel Ortega Cantero (Castilla-La Mancha University, Espanha)

Manuel Palomo-Duarte (Department of Computer Science, University of Cadiz, Espanha)

Maria João Gomes (Universidade do Minho, Portugal)

Maria João Silva (Escola Superior de Educação de Lisboa, Portugal)

Maria José Marcelino (University of Coimbra, Portugal)

Maribel Miranda Pinto (Universidade Aberta, Portugal)

Martín Llamas Nistal (atlanTTic research center, Universidade de Vigo, Espanha)

Maximiliano Paredes Velasco (Universidad Rey Juan Carlos, Espanha)

Miguel Redondo (University of Castilla-La Mancha, Espanha)

Pedro Rito (Instituto Politécnico de Viseu, Portugal)

Rita Cadima (Instituto Politécnico de Leiria, Portugal)

Rosa M. Carro (Universidad Autonoma de Madrid, Espanha)

Rosa Vicari (Universidade Federal do Rio Grande do Sul, Brasil)

Sílvia Roda Couvaneiro (Instituto Politécnico de Setúbal, Portugal)

Susana Nieto Isidro (University of Salamanca, Espanha)

Teresa Pessoa (University of Coimbra, Portugal)

Yannis Dimitriadis (University of Valladolid, Espanha)

Comissão Organizadora

Miguel Figueiredo (Instituto Politécnico de Setúbal, Portugal) **Presidente**

João Torres (Instituto Politécnico de Setúbal, Portugal) **Copresidente**

Ana Chambel (Instituto Politécnico de Setúbal, Portugal)

Ana Rute Martins (Instituto Politécnico de Setúbal, Portugal)

Elsa Ferreira (Instituto Politécnico de Setúbal, Portugal)

João Grácio (Instituto Politécnico de Setúbal, Portugal)

José Miguel Freitas (Instituto Politécnico de Setúbal, Portugal)

Maria do Rosário Rodrigues (Instituto Politécnico de Setúbal, Portugal)

Sílvia Roda Couvaneiro (Instituto Politécnico de Setúbal, Portugal)

Nota introdutória

O Simpósio Internacional de Informática Educativa (SIIE) é um fórum internacional para a apresentação e discussão dos mais recentes avanços na investigação sobre tecnologias educativas e a sua aplicação prática em processos educativos. Também visa reunir investigadores, representantes institucionais e docentes para partilharem perspetivas, conhecimentos e experiências.

A 25.ª edição do Simpósio teve como foco sistemas, plataformas, pedagogias e educação baseada na prática em e-learning e b-learning, incluindo o uso de simuladores, sistemas de realidade aumentada, sistemas de realidade virtual e laboratórios virtuais, bem como pensamento computacional, programação e robótica educativa.

Sessões plenárias

Painel

Comunicações

Índice dos artigos

A utilização do software *Pixton* como recurso pedagógico no processo de ensino e aprendizagem 1

Contributos e potencialidades da aplicação digital WheelDecide numa turma do 1.º CEB 7

Hacia una propuesta para la medición de la calidad en uso de sistemas CSCL para el aprendizaje de la programación: el caso de estudio de COLLECE 2.0 13

Exploring the Potential of Modern Board Games to Support Computational Thinking 19

Young people's digital competences: does gender matter? 27

Educational robotics and programming in inclusive educational settings: a scoping review 33

Potencialidades do uso da Gamificação em um Curso Online Aberto e Massivo 38

The portfolio as a tool for learning and assessment in the Internship in Teaching Informatics 44

Propuesta de enseñanza de la programación a futuros profesores de Educación Primaria basada en el uso de la Taxonomía de Bloom 50

Formação Pedagógica de Professores do Ensino Superior: Comunicação e Colaboração com Tecnologias Digitais 56

Aprendizagem Baseada em Jogos: Uma Estratégia para o Ensino de Conteúdos Programáticos em Contexto de Sala de Aula 62

GeoGebra applet to learn programming and debugging in mathematics lessons 67

Participatory design of a high-fidelity prototype of an essential learning curricular tool 72

STEM Career Aspirations Among Portuguese Secondary School Students 78

OntoCnE, characterizing Learning Resources for training Computational Thinking 83

In heaven as on earth: The performance of students is as good as it is the digraph that describes their behavior 89

Reto de ecuaciones, una aplicación de apoyo a la clase de matemáticas 96

Promoting global awareness of the SDGs in the classroom through the SDGCalendar platform 102

E-Assessment Systems: An Evaluation Framework from the Perspective of Higher Education Experts 108

Positive and negative factors affecting the initiative for the inclusion of ICT in the secondary education curriculum in Namibe-Angola 114

The Use of Immersive Virtual Reality in Educational Practices in Higher Education: A Systematic Review 119

Wikipedia and MediaWiki: two key elements of a Wikipedagogy practice 124

Wikipedia in University Program: meta-analysing the actors in the lusophone page 129

Inteligência Artificial e investigação académica: um estudo exploratório com estudantes de mestrado 134

Bacia do Rio Doce - aspectos sócio-históricos, econômicos e ambientais: formação continuada híbrida no Projeto Rio Doce Escolar 140

Class Type Preferences in Informatics Engineering: before, during, and after the pandemic 146

Integration of Large Learning Models into Higher Education: A Perspective from Learners 152

Development of Computational thinking through the micro:bit: an experience in the ICT subject 158

Aprender enseñando: creación de tutoriales con TutoApp en el ámbito de formación profesional 163

Uso de Modelo Grande de Lenguaje en un curso de Bases de Datos: una visión vía TAM 168

Assessment of learning Mediated by Digital Technologies in the Context of Environmental Education: Teacher Training through a MOOC Course........ 173

Uso de micro mundos en el aprendizaje de conceptos básicos de programación, para futuros profesores de educación infantil 179

PRO(G)NATURA: technologie and outdoor education as a complement to improve the child learning process........ 185

Instrumentos para la evaluación de la percepción y la actitud hacia el pensamiento computacional 191

Contradictions in the adoption of Distance Education in Brazilian education during Covid-19 197

Dificulades en una Experiencia de Aula Invertida con Evaluación Continua y Autorregulación 202

Jogos Educativos Digitais para aprender matemática........ 208

Videojuego Educativo "Scratch Estadístico" para la enseñanza de Estadística 214

Scaffolding for Visual Programming: Design and Evaluation of a Model-Driven Engineering Approach........ 220

Esquemas de Metadatos Reconfigurables con Elementos Multivaluados: Hacia la Gestión de Repositorios Educativos Mediante Gramáticas Formales en la Plataforma Clavy........ 226

Aprendizagem colaborativa no ensino superior: o papel do *Padlet* no desenvolvimento de competências de escrita académica........ 232

Neuroeducation: Guidelines for Computational Thinking training 237

Un rastreador para la formación del profesorado en el lenguaje ScratchJr 243

A study on the Motivation of Computer Science Students to Learn Programming........ 249

Teach the importance of logic (programming) in Computer Science and why it is important. 255

Application for the Academic Management of Supervised Clinical Practicum in *Nursing Degree* 261

HerStory: combating gender stereotypes by highlighting women's contribution to the history of societies........ 267

Instructional Design Models for Immersive Virtual Reality - A systematic literature review... 272

Formação docente na Universidade Federal do ABC durante a pandemia do Covid 2019: Resultados, Desafios e Perspectivas Futuras........ 279

e-Campus: concept and design of a virtual campus to support Distance Learning in a Polytechnic Institute........ 286

A emergência da algoritmia no 1.º ano de escolaridade: um estudo no âmbito das Aprendizagens Essenciais de Matemática 291

Reflexões sobre uma UC de tecnologias na formação inicial de professores: a perspetiva dos estudantes. 298

Reflexões em torno de um projeto de robótica educativa na Educação de Infância e no 1.º Ciclo do Ensino Básico..........304

Project-Based Learning in the curricular unit ICT in Professional Contexts – perceptions of Sociocultural Animation students 310

School dropout in the Federal Network Education of Brazil: is it an inherent individual attribute or it lies on setting conditions? 315

Sessões plenárias

José António Moreira

José António Moreira é doutorado e mestre em Ciências da Educação pela Universidade de Coimbra. É Licenciado em História da Arte pela mesma Universidade

Para além disso, possui um Pós-Doutoramento em Tecnologias Educacionais e da Comunicação, também pela Universidade de Coimbra e uma pós-graduação em Multimédia pela Faculdade de Engenharia da Universidade do Porto, e ainda um Curso de Realização Cinematográfica.

É Professor Associado com Agregação no Departamento de Educação e Ensino a Distância e Coordenador da Unidade de Desenvolvimento dos Centros Locais de Aprendizagem da Universidade Aberta (UAb). Investigador e Coordenador do Centro de Estudos de Pedagogia do Ensino Superior do Centro de Estudos Interdisciplinares (CEIS20) da Universidade de Coimbra e Coordenador Estrangeiro do Grupo de Investigação em Educação Digital da Universidade do Vale do Rio dos Sinos (GPe-dU – UNISINOS/ CAPES-CNPq), Brasil.

Professor Colaborador dos Programas de Pós-Graduação em Educação, Contemporaneidade, Gestão e Tecnologias Aplicadas à Educação da Universidade do Estado da Bahia (UNEB) e Professor Convidado do Curso de Especialização em Educação e Tecnologias da Universidade Federal de São Carlos (UFSCar), Brasil.

Desde 2020 é coordenador do Curso de Docência Digital para Docentes do Ensino Superior da Universidade Aberta.

Atualmente coordena o Projeto "Educação Digital em Estabelecimentos Prisionais em Portugal (UAb) e é Investigador Estrangeiro Responsável pelo Programa Institucional de Internacionalização CAPES/PRINT: "Transformação Digital e Humanidades: Educação, Comunicação e Tecnologias" (UNISINOS/UAb).

O PARADIGMA EMERGENTE DA EDUCAÇÃO DIGITAL EM REDE. COMPETÊNCIAS E FORMAÇÃO NECESSÁRIAS.

Resumo

A evolução das tecnologias e das redes de comunicação propiciaram o surgimento de uma sociedade reticular marcada por mudanças acentuadas na economia e no mercado de trabalho, impulsionando o nascimento de novos paradigmas, modelos, processos de comunicação educacional e novos cenários de ensino e de aprendizagem. Tendo, pois, em consideração este contexto, o objetivo desta comunicação é apresentar a proposição de um paradigma que se define e se constrói, também em espaços virtuais, em rede e que necessita de atores humanos "competentes" que compreendam como se pode construir uma educação de qualidade nesses cenários emergentes.

Helen Crompton

A Dra. Helen Crompton é a Diretora Executiva do Instituto de Investigação para a Inovação Digital na Aprendizagem (RIDIL) da ODUGlobal e Professora de Tecnologia Instrucional na Old Dominion University (ODU). É também a Diretora do Laboratório de Realidade Virtual da ODU. Possui 30 anos de experiência no setor da educação e um doutoramento em tecnologias educativas e educação matemática pela Universidade da Carolina do Norte em Chapel Hill. Recebeu inúmeros prémios nos EUA e no seu país natal, Inglaterra, pelo seu trabalho na integração das tecnologias, incluindo o prémio SCHEV para o Professor Extraordinário da Virgínia. É consultora de vários governos e organizações bilaterais e multilaterais, como as Nações Unidas e o Banco Mundial, sobre temas relacionados com a tecnologia educativa. É também consultora de organizações como a International Society for Technology in Education (ISTE). Faz parte da lista dos 2% melhores cientistas do mundo da Universidade de Stanford e publicou mais de 150 artigos sobre integração tecnológica.

COMO A IA GENERATIVA ESTÁ A MUDAR A PAISAGEM EDUCACIONAL

Resumo

Embora a Inteligência Artificial (IA) já exista há algumas décadas, recentemente ela fez avanços poderosos que mudaram o cenário educacional. Programas de IA generativa, como o ChatGPT, fizeram com que os educadores questionassem como as atividades são projetadas e como avaliamos o conhecimento dos alunos. Embora existam limitações para esses programas de IA, o potencial é abundante em fornecer suporte aos educadores no ensino, incluindo ajuda na redação de planos de aula, avaliações, resumos e ideias de ensino, e suporte aos alunos na aprendizagem, como tutoria personalizada, preparação para exames e estratégias de estudo. Esta sessão fornecerá o que precisa saber para que os alunos usem a IA de forma positiva e adequada bem como estratégias concretas para melhorar o ensino e a aprendizagem com essas ferramentas.

Painel - Temas atuais em tecnologias digitais no processo de ensino e aprendizagem

Neste painel, reunimos três professores para debater com a assistência três temas que consideramos atuais e pertinentes, no contexto da utilização das tecnologias digitais no processo de ensino e aprendizagem. Martinha Piteira é Professora Adjunta na Escola Superior de Tecnologia do Instituto Politécnico de Setúbal e virá falar-nos de Gamificação. Celestino Magalhães é Professor Adjunto na Escola Superior de Educação do Instituto Piaget de Vila Nova de Gaia e trará a debate o tema da Realidade Virtual. João Piedade é Professor Auxiliar no Instituto de Educação da Universidade de Lisboa e trará para o painel o tema do Pensamento Computacional.
Pedimos a cada um destes participantes que preparassem uma pequena intervenção inicial. Em seguida deixamos os resumos das suas primeiras intervenções, bem como pequenas notas biográficas de cada um deles.

Martinha Piteira

Martinha Piteira é Professora Adjunta no Instituto Politécnico de Setúbal – Escola Superior de Tecnologia. A Martinha é doutorada em Ciências e Tecnologias da Informação e Mestre em Gestão de Sistemas de Informação, pelo Instituto Universitário de Lisboa (ISCTE-IUL).
Os seus interesses de investigação incluem a avaliação dos sistemas de informação, nas vertentes de adoção da tecnologia e pedagógica, concretamente dos sistemas de eLearning, da Gamificação e das Tecnologias Educacionais. A Ética na Inteligência Artificial, a Usabilidade e Acessibilidade são também áreas de interesse de investigação. A sua investigação está publicada em revistas científicas, conferências nacionais e internacionais, tais como a ACM, com indexação Scopus. Nos seus trabalhos de investigação a Martinha realizou um estudo de adoção da gamificação no ensino da programação no Ensino Superior. Desenhou e implementou um MOOC gamificado para aprendizagem da programação. Participou em projetos Europeus, tendo colaborado no desenvolvimento de produtos, com uma forte aplicação das abordagens e técnicas de gamificação.

Celestino Magalhães

Celestino Magalhães é Mestre em Sistemas de Informação e mestre em TIC – Tecnologias de Informação e Comunicação: Especialização Multimédia.
Professor Adjunto e Coordenador da Pós-Graduação em TIC: Ecossistemas Híbridos de Aprendizagem na ESDE – Escola Superior de Desporto e Educação no Instituto Piaget Vila Nova de Gaia.
As áreas de interesse incluem Matemática, Ciências, Tecnologia, Engenharia e Tecnologia Educativa. Encontra-se na fase de conclusão do doutoramento em Ciências da Educação, na especialização de Tecnologia Educativa, no Instituto de Educação da Universidade do Minho. Os interesses de investigação são o uso criativo de vídeo em educação e como a edição de vídeo usando smartphones e tablets pode ser uma estratégia pedagógica na compreensão de conceitos complexos em STEAM (Ciências, Tecnologia, Engenharia, Artes e Matemática). Co Leader do Google Educator Group - GEG SUPERTABi Portugal. Professor de Programação e Robótica.

João Piedade

João Piedade é Professor Auxiliar do Instituto de Educação da Universidade de Lisboa. Doutorado em Educação na especialidade de Tecnologias da Informação e Comunicação na Educação e Mestre em Tecnologias e Metodologias em E-learning pela Universidade de Lisboa, e Licenciado em Engenharia Informática pelo Instituto Politécnico da Guarda. Investigador da Unidade de Investigação e Desenvolvimento em Educação e Formação do Instituto de Educação da ULisboa. Coordena a comissão científica do Mestrado em Ensino da Informática e o Curso Pós-graduado de Robótica e Tecnologias Emergentes no Ensino Básico. Dedica-se ao ensino e investigação nos domínios da didática da informática, da aprendizagem enriquecida com tecnologias digitais, programação, robótica educativa, pensamento computacional e tecnologias emergentes. Atualmente, orienta diversos projetos de doutoramento e mestrado no domínio do pensamento computacional no ensino da informática e da matemática. É autor e coautor de diversas publicações em revistas nacionais e internacionais com revisão por pares.

Intervenções iniciais

Gamificação na Educação: Abordagens, Desafios e Potencial Transformador

A gamificação é o processo de incorporar elementos de jogo em contextos que não são originalmente de natureza lúdica (Deterding et al., 2011). Estes elementos de jogo são caracterizados pela utilização de pontos, medalhas, níveis, barras de progresso, quadros de honra, moeda virtual, avatares, entre outros. As implementações comuns da gamificação aplicam esses elementos em diversos contextos (Kapp, 2012). Apesar de ser ocasionalmente associada ao entretenimento de forma equivocada, a gamificação tem um propósito que transcende o mero entretenimento, visando a melhoria da experiência e a modificação de comportamentos. Ela tem sido aplicada em uma variedade de áreas, incluindo Marketing, Saúde, Educação, Bancária, entre outras.

No contexto da Educação, a aplicação da gamificação tem como finalidade envolver os estudantes nas atividades de aprendizagem, estimulando o interesse por atividades ou conteúdos que podem ser menos atrativos ou mais complexos. A integração da gamificação no processo educativo pode seguir diferentes abordagens, mas o objetivo central é criar experiências imersivas, proporcionando o chamado 'estado de flow'. Isso requer a harmonização dos objetivos de aprendizagem com a motivação dos estudantes, bem como outros fatores associados. A gamificação é uma estratégia multifacetada com aplicações em diversos campos, focada na inovação e no envolvimento dos estudantes, com potencial para transformar as práticas pedagógicas (Seaborn & Fels, 2015).

Despertar Emoções: O Impacto Transformador da Realidade Virtual na Aprendizagem

A Realidade Virtual (RV) surgiu como uma ferramenta poderosa na educação, oferecendo experiências imersivas que transformaram e transformam significativamente o processo de aprendizagem. Com esta comunicação, exploramos o impacto significativo da RV na educação, com ênfase especial no despertar das emoções dos alunos e na forma como estas influenciam todo o processo de aprendizagem.

Estabelecemos um referencial teórico, discutindo os princípios básicos da Realidade Virtual e as suas aplicações educativas. Salientamos como a RV cria um ambiente de aprendizagem rico e envolvente, onde os conceitos abstratos e mais complexos, ganham vida e os alunos podem interagir com os recursos de aprendizagem de novas maneiras e mais estimulantes.

Focamo-nos ainda na relação entre emoção e aprendizagem, destacando como as emoções influenciam a memória, a motivação e o envolvimento dos alunos nas atividades de aprendizagem. Exploramos como a RV, ao criar experiências significativas emocionalmente, pode aumentar a retenção de informações e promover uma compreensão mais profunda dos temas abordados, produzindo conhecimento de uma forma mais objetiva e duradoura.
Apresentamos, ainda, exemplos práticos que ilustram o impacto positivo da RV na educação. Os exemplos demonstram como a RV pode ser utilizada para criar emoções positivas e promover uma aprendizagem mais eficaz e significativa para os alunos.
Adicionalmente, discutimos os desafios e considerações éticas associadas à utilização da RV em contextos educativos, incluindo questões de acessibilidade, segurança e o equilíbrio entre a realidade e a virtualidade.
Como considerações finais, oferecemos recomendações práticas para educadores e professores que desejem integrar a Realidade Virtual nos seus métodos de ensino, destacando algumas práticas para maximizar o impacto emocional e educativo desta tecnologia.
Concluímos, sublinhando a Realidade Virtual como um meio poderoso para despertar emoções e enriquecer a experiência educativa dos nossos alunos, transformando a forma como os alunos percebem, interagem, produzem e "absorvem" o conhecimento.

Pensamento Computacional na Escola: do conceito às práticas pedagógicas e de investigação

O termo Pensamento Computacional (PC) tem vindo a ganhar relevância em termos educativos e de investigação desde a sua definição por Jeannette Wing em 2006. Apesar do conceito ter sido apresentado em 2006, encontra fundamentos nas ideias poderosas de Seymour Papert apresentadas numas das suas obras de referência "Mindstorms: Children, computers, and powerful ideas". A ideia de micromundos (ambientes) computacionais, práticas computacionais e perspetivas computacionais estão muito presentes nas conceções de Papert sobre a forma como as crianças aprendem através da interação com artefactos computacionais. Michael Lodi e Simone Martini, num artigo de 2021, discutem o conceito à luz dos fundamentos epistemológicos de Papert e de Wing, apresentando os pontos em comum e as principais divergências. Vários países têm procurado, nos últimos anos, desenvolver iniciativas de integração do PC nos currículos dos ensinos básicos e secundário. No contexto português o PC está formalmente integrado nas aprendizagens essenciais das disciplinas de Tecnologias da Informação e Comunicação e de Matemática. Nesta comunicação procuraremos caracterizar o conceito de pensamento computacional, analisar a sua integração curricular e exemplificar práticas pedagógicas e de investigação.

Referências

Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011). Gamification. using game-design elements in non-gaming contexts. In *CHI'11 extended abstracts on human factors in computing systems* (pp. 2425-2428).

Kapp, K. M. (2012). *The gamification of learning and instruction: game-based methods and strategies for training and education*. John Wiley & Sons.

Lodi, M., & Martini, S. (2021). Computational Thinking, Between Papert and Wing. *Science & Education*, 30, 883-908. https://doi.org/10.1007/s11191-021-00202-5

Papert, S. (1980). Mindstorms: Children, computers, and powerful ideas. New York: Basic Books, Inc.

Seaborn, K., & Fels, D. I. (2015). Gamification in theory and action: A survey. *International Journal of human-computer studies*, *74*, 14-31.

A UTILIZAÇÃO DO SOFTWARE *PIXTON* COMO RECURSO PEDAGÓGICO NO PROCESSO DE ENSINO E APRENDIZAGEM

Henrique Gil
Age.Comm- Instituto Politecnico de Castelo Branco
Castelo Branco, Portugal
hteixeiragil@ipcb.pt

Joana Vitorino
Escola Superior de Educação - Instituto Politecnico de Castelo Branco
Castelo Branco, Portugal
jfbvitorino@hotmail.com

***Abstract*— Since Information and Communication Technologies (ICT) are quite embedded in everyday life, it is necessary to think about the potential that they can also present in education. In this way, it was intended to understand the potential that the *Pixton* software could bring to the teaching and learning process. Since it is a versatile, creative, and motivating software, an attempt was made to investigate the use of *Pixton* software as a teaching and learning strategy, to understand what its contributions are to the teaching and learning process. The use of the *Pixton* software proved to be an adequate resource and promoter of innovative contexts in the teaching and learning process. In general, and considering the results obtained, this software is motivating, creative, playful, adaptable, and transversal to all curricular areas of the 1st Cycle of Basic Education. In this context, *Pixton* proved to be a promoter of better levels of educational success, thanks to the high levels of interest, commitment, motivation, and involvement on the part of the students that were observed in the activities developed.**

Keywords—1st Cycle of Basic Education, Pixton, Supervised Teaching Practice, Educational Software, Information and Communication Technologies.

Resumo— Estando as Tecnologias de Informação e Comunicação (TIC) bastante inseridas no quotidiano, é necessário pensar no potencial que elas também podem apresentar na educação. Desta forma, pretendeu-se compreender as potencialidades que o software Pixton poderá trazer para o processo de ensino e aprendizagem. Por se tratar de um software versátil, criativo e motivador, procurou-se investigar a utilização do software Pixton como estratégia de ensino e aprendizagem, para compreender quais são suas contribuições para o processo de ensino e aprendizagem. A utilização do software Pixton revelou-se um recurso adequado e promotor de contextos inovadores no processo de ensino e aprendizagem. De uma forma geral, e tendo em conta os resultados obtidos, este software é motivador, criativo, lúdico, adaptável e transversal a todas as áreas curriculares do 1.º Ciclo do Ensino Básico. Neste contexto, o Pixton revelou-se um promotor de melhores níveis de sucesso educativo, graças aos elevados níveis de interesse, empenho, motivação e envolvimento por parte dos alunos que foram observados nas atividades desenvolvidas.

Palavras-chave—1.º Ciclo do Ensino Básico, Pixton, Prática de Ensino Supervisionada, Software Educativo, Tecnologias da Informação e da Comunicação.

I. INTRODUÇÃO

As Tecnologias da Informações e Comunicação (TIC) encontram-se cada vez mais inseridas na sociedade. Tendo esta realidade em consideração, é importante compreender que a integração das TIC na educação é necessária, pois conta com diversas potencialidades como, por exemplo, auxiliar e tornar mais atrativo o processo de ensino e aprendizagem, tanto para os alunos, como para os docentes. É nesta área que optamos por realizar um estudo sobre a utilização do software *Pixton* como recurso pedagógico no processo de ensino e aprendizagem, numa turma de 4.º ano do 1.º Ciclo do Ensino Básico (1.ºCEB). A escolha do *Pixton* advém de acreditarmos que este possa ser um recurso educativo capaz de criar ambientes motivadores, lúdicos e interessantes, principalmente para os alunos, de modo a promover o sucesso educativo numa melhor consolidação de conteúdos. Começamos o artigo com um breve enquadramento teórico da investigação, no âmbito da Prática de Ensino Supervisionada do curso de Mestrado em Educação de Infância e Ensino do 1. Ciclo do Ensino Básico focando nas TIC e nas potencialidades do software educativo em geral, e do *Pixton* em particular, o qual foi enquadrado pedagogicamente como software educativo. De seguida, apresentamos, resumidamente, a metodologia utilizada na investigação e os dados obtidos. Por fim, apresentamos algumas considerações finais, assinalando as principais conclusões e limitações da investigação.

II. ENQUADRAMENTO TEÓRICO

A. As TIC na sociedade e em contexto educativo

A inclusão das TIC na sociedade veio transformar o nosso quotidiano, o funcionamento da sociedade e, por sua vez, tem consequências no sistema educativo. O desenvolvimento das sociedades influencia o modo como os cidadãos se organizam, trabalham, ensinam e aprendem. Deste modo, o avanço e os processos de mudança, no seu todo, levaram a alterações e evoluções das quais as tecnologias digitais não ficaram de fora. Uma vez que as TIC têm vindo a assumir um papel cada vez mais importante na vida quotidiana, estas encontram-se mais presentes na comunidade. Neste sentido, [1] veio afirmar que as TIC "(…) representam uma força determinante do processo de mudança social, surgindo como a trave-mestra de um novo tipo de sociedade, a sociedade de informação." Deste modo, [2] referem que esta geração é "(…) a primeira geração de adolescentes que contactou com a internet e com os telemóveis, que em muitos aspetos se apropriou destas tecnologias, ditou tendências e estabeleceu práticas."

Na opinião de [3], "(…) apesar da existência de várias medidas, de investigações e de relatórios que apontam para a necessidade de uma utilização 'rotineira' das TIC, ainda não se pode afirmar que estas práticas já se encontram instituídas nas escolas portuguesas." Desta forma, e pela representação que têm vindo a ganhar na sociedade, é importante retratar e refletir sobre o papel significativo que estas têm no processo de ensino e aprendizagem, bem como tentar introduzi-las mais nas escolas a fim de oferecer novas e diferentes formas de aprender. Pois, e considerando [2], "(…) a utilização das tecnologias digitais nas escolas é, ainda, durante o primeiro ciclo, incipiente. As crianças que contactam mais com tecnologias digitais nas escolas (…) têm informática como atividade extracurricular ou frequentam escolas privadas." Também [4], vai ao encontro do mencionado anteriormente quando refere que devido à COVID-19 existiu uma rápida evolução das tecnologias, mas, ao mesmo tempo, se revelaram altos índices de exclusão social e digital. Assim sendo, é importante que a escola seja a primeira a refletir sobre a necessidade de enquadrar os seus alunos no contexto real e atual que a sociedade se encontra, de modo a formar seres capazes e aptos de ultrapassar as dificuldades, mas também de proporcionar aprendizagens atuais num contexto social cada vez mais digital.

Em primeiro lugar, é necessário compreender que a introdução das tecnologias digitais não irá, nem deverá, substituir todos os meios tradicionais que a escola oferece, ou até mesmo o próprio professor. Esta introdução deve ser vista como um ponto de mudança na aprendizagem e na interação que existe entre o professor e o aluno, e o aluno e o professor. De acordo com [5], as TIC apresentam um papel extraordinário visto serem "(…) meios democratizadores por excelência no acesso ao saber, na observância de uma aprendizagem que respeita o ritmo de cada aluno e no desenvolvimento de competências individuais; ao mesmo tempo, permitem novas formas de comunicação, de linguagem, de situações comunicacionais novas, mais próximas seguramente dos alunos." Deste modo, a escola deve proporcionar e introduzir no currículo uma aprendizagem integrada e feita através das tecnologias digitais.

Como referem [6], as TIC apresentam um papel importante e positivo, porque operam como uma porta de entrada que é capaz de aperfeiçoar e capacitar os docentes, de lhes oferecer formação contínua, e de "(…) tornar os enfrentamentos pedagógicos mais atrativos e dinâmicos (…)", enquanto promove a melhoria da qualidade do ensino e espera a oportunidade do desenvolvimento da cidadania. Também [7] vai ao encontro do referido quando menciona que "(…) educação e tecnologias são indissociáveis", pois defende que a educação é o processo de desenvolvimento de capacidades que visa uma melhor integração individual e social. Neste contexto [7] ainda refere que para se desenvolverem essas capacidades é necessário que "(…) se utilize a educação para ensinar sobre as tecnologias que estão na base da identidade e da ação do grupo e que se faça uso delas para ensinar as bases dessa educação." Contudo, é importante considerar que o professor também apresenta um papel fulcral na utilização das TIC no contexto educativo, pois é fundamental que este entenda a relevância de acompanhar os seus alunos, ao aceitar as ideias e as propostas dos discentes num contexto mais digital. Para além desta dimensão e considerando [8] devido às alterações constantes no setor educacional "(…) os professores devem ser multifuncionais, não chega ser apenas professor, mas devem ser capazes de propiciarem uma visão mais holística para que possam transmitir confiança e uma maior segurança aos alunos no processo de ensino-aprendizagem." Neste sentido, salienta-se ainda que o professor deve despertar os seus alunos a fim de atingir neles o prazer, como um todo, pelos conteúdos a aprender. Deste modo, o professor deve dominar estas ferramentas digitais para que consiga torná-las rentáveis no contexto de sala de aula. Cabe ao docente promover a introdução das TIC de uma forma não abrupta, mas sim criativa, diligente e controlada, considerando sempre que estas podem ser capazes de incrementar as aprendizagens que os alunos adquirem. No ponto de vista de [9] esta constante mudança e adaptação exige aos docentes "(…) «pensar fora da caixa», fazer diferente, arriscar novas abordagens com os seus alunos, nas suas salas de aula, nas suas escolas. Depois partilhar e colaborar com outros professores."

No seguimento do referido anteriormente, não pode ser descurada a formação e a adaptação do docente na inclusão, adaptação e utilização das TIC, uma vez que os alunos se adaptam com bastante facilidade a esta "nova" realidade digital, pois encontram-se cada vez mais ligados às TIC sob as mais diversas formas. Na opinião de [10] os professores são um "(…) elemento essencial no processo de utilização, integração e apropriação das TIC no contexto educativo." Ainda que as escolas ofereçam equipamentos tecnológicos, o modo como incentivam a sua utilização deve também ser considerado, pois importa compreender se a utilidade que lhes são dadas contribui, ou não, para a melhoria do sistema educativo. Isto porque de pouco serve uma escola oferecer e ter equipamentos tecnológicos quando a exploração que é feita é pobre no que concerne à promoção de contextos mais criativos e inovadores para a aquisição das aprendizagens.

Em Portugal foram promovidos diversos projetos para promover a introdução das TIC. Entre 1985 e 1994, o Ministério da Educação criou o Projeto MINERVA, com a finalidade de promover a utilização, como recurso educativo, do computador. Também em 1996, o Programa Nónio Século XXI foi apresentado, com o objetivo de produzir e aplicar o uso da TIC em contexto educativo. Numa linha temporal mais próxima, foi criado, pelo Ministério da Educação o Perfil do Aluno à Saída da Escolaridade Obrigatória (PA) e as Orientações Curriculares para as Tecnologias de Informação e Comunicação (OCTIC). Para além de tudo isto, é possível encontrar na alínea 3 do artigo 13.º do Decreto-Lei n.º 55/2018 de 6 de julho que a matriz curricular-base deve contar com as componentes das TIC como elementos "(…) de integração curricular transversal potenciada pela dimensão globalizante do ensino, constituindo esta (…) uma área de natureza instrumental, de suporte às aprendizagens a desenvolver." Tendo em conta o referido, a escola deve assegurar aos seus alunos um currículo potenciador de aprendizagens que não exclua, mas sim, utilize e integre as TIC em todas as áreas disciplinares. Segundo [11], os alunos devem aprender considerando quatro domínios – "cidadania digital", "investigar e pesquisar", "comunicar e colaborar" e "criar e inovar" – de forma articulada e que vise o desenvolvimento das competências do PA. Convém ainda referenciar a Equipa de Recursos e Tecnologia Educativa da Direção Geral de Educação que atualmente promove apoio e disponibiliza vários recursos digitais para alunos e para professores.

B. *O software educativo*

Num momento inicial, é importante voltar a referir que na qualidade do ensino e no processo de ensino e aprendizagem, tanto o ambiente como o uso dos softwares podem estimular e motivar os alunos. De acordo com [12], "(…) os elementos que mais contribuíram para que o computador se tornasse um dos mais versáteis mediadores tecnológicos no campo da educação foram os programas e os protocolos de comunicação, que recebem o nome de software." A definição de software pode ser um trabalho com um certo nível de dificuldade, pois existem diversas conceções e estas têm sofrido reformulações ao longo do tempo. No entanto, é importante distinguir software educativo (SE) de software educacional. De um modo geral, o SE é construído de raiz com o intuito de ser utilizado no processo de ensino e aprendizagem. Já o software educacional é um qualquer software, incluindo o educativo, que possa ser enquadrado e contextualizado didaticamente, ou seja, a sua utilização pode ser encaixada nos objetivos e nos conteúdos a lecionar. Também [13], vai ao encontro do referido, quando afirma que "(…) o que confere ao software o seu carácter de ferramenta educacional é a sua utilização no processo de ensino e aprendizagem."

Na perspetiva de [14], citado em [15], existem várias vantagens que os softwares educativos nos apresentam, como por exemplo: aumentar a atenção e o envolvimento dos alunos; introduzir os alunos no mundo das tecnologias; tornar as aulas mais dinâmicas; encontrar novas e originais formas de motivar e de despertar o interesse dos alunos; tornar a educação mais eficiente; entre outras. A utilização correta dos SE permite que estes possam ser considerados ferramentas educativas. Todavia, o SE preocupa-se, essencialmente, no alcance dos objetivos educativos delineados no processo de ensino e aprendizagem. Isto justifica-se na "justificação" da sua conceção, pois este foi gerado para que a sua utilização fosse como um meio didático que pudesse ser utilizado em qualquer área curricular. As TIC permitem que a informação, seja ela através de texto, imagens ou outros, circule de um para outro local, independentemente da distância. Por sua vez, possibilita que a informação chegue às salas de aula e auxilie os alunos na compreensão de conceitos que se apresentem complexos. O professor, tendo em conta as opiniões já enunciadas, pode utilizar as TIC e os softwares como um recurso que contribui para o desenvolvimento do processo de ensino e aprendizagem, seja através de novas formas de ensinar ou de motivar todos os participantes nestes processos e contextos pedagógicos no sentido de fomentar aprendizagens junto dos alunos. Para além das dimensões já enunciadas, o SE pode ser uma ferramenta bastante pertinente no combate ao insucesso escolar, através da motivação e do despertar de interesses. Pois, segundo [16] o SE poderá ser "(…) uma estratégia para dar respostas diferenciadas aos diferentes níveis de aprendizagem. Pretende-se que o SE tenha a dupla missão de ajudar a aprender e de ajudar a brincar de uma forma simples e divertida." Em suma, o SE promove condições para a aprendizagem, a exploração, e a compreensão. Todavia, o que é preciso, tendo sempre como núcleo o conteúdo, é transformar a metodologia clássica de ensino, em momentos de lazer, de resposta e de respeito, quer pelas especificidades quer pela paridade de cada um, num contexto colaborativo.

C. *O software Pixton*

A presença das TIC nas escolas, no auxílio do processo de ensino e aprendizagem e no lazer dos cidadãos, tem vindo a aumentar. No contexto educativo, as TIC permitem, citando [17], "(…) estruturar objetivos de aprendizagem e conteúdos, combinando tecnologias, bem como interações presenciais." Desta forma, apresenta ser benéfico a inclusão das TIC em qualquer área curricular. Em primeiro lugar, é necessário compreender, de forma generalizada o que é a Banda Desenhada (BD). A BD é uma série de desenhos que representam uma história ou uma situação, que se encontra, normalmente, dividida em retângulos sequenciais, ou seja, em tiras. A utilização da BD como instrumento pedagógico já era utilizada, pois a visualização desta nos manuais escolares portugueses já se encontrava presente, pelo menos, nos finais do século XX. Para além disto, a BD está integrada nos Programas e Metas Curriculares do Português do Ensino Básico, estando presente logo nos dois primeiros anos do 1.ºCEB. Na investigação realizada, as TIC foram incluídas em contexto educativo através de um software que permite criar BD de forma rápida e gratuita, através de diversas ferramentas: o *Pixton*. Este recurso pode ser acedido através do website: http://pixton.com/. Na figura 1 pode observar-se a webpage do software *Pixton*:

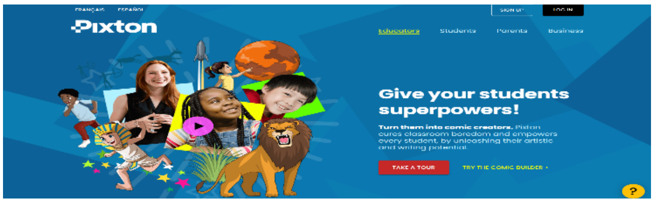


Fig. 1. Página de apresentação do software *Pixton*

Para aceder ao *Pixton* é necessário ter uma conta. Esta conta pode ser de «professor», «estudante», «pai» ou «empresa». Depois de selecionada uma destas opções, é necessário fazer o registo a partir do e-mail ou dos dados da conta do Facebook, e inserir uma password. Se o utilizador selecionar a opção de «professor» será necessário introduzir dados relativos à escola onde leciona e o ano escolar. Isto permite que apenas professores/educadores criem conta nesta opção. No caso desta investigação, foi criada uma conta de «professor».

Após criar a conta e iniciar sessão, abre uma página (fig. 2) onde é possível criar as BD e explorar as diversas funcionalidades do software.

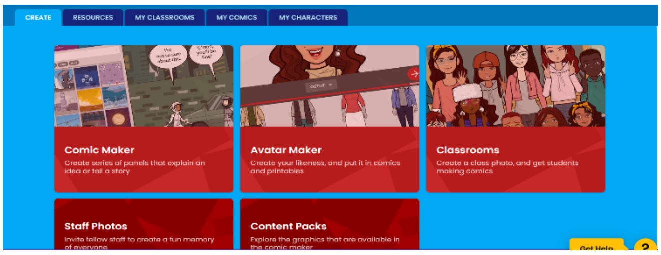


Fig. 2. Separador "*Create*" (Criar Banda Desenhada e Personagens)

No separador "*create*" é possível criar a BD ("*comic maker*"), um avatar/personagem ("*avatar maker*"), uma turma e as suas personagens ("*classrooms*"), tirar uma "fotografia de grupo", onde cada um se encontra representado pela sua personagem ("*staff photo*") e explorar materiais extra no momento da criação ("*content packs*").

No separador "*resources*" (fig. 3), é possível ver/utilizar ideias de outros utilizadores para lecionação ("*lesson ideas*"), ter acesso a um guia que auxilia na criação de BD ("*comic school*"), ver/utilizar propostas de começos de BD ("*story starters*"), aceder a um guia que explica como utilizar o *Pixton* na avaliação diagnóstica, formativa e sumativa ("*assessment*"), autoavaliar a construção da BD ("*interactive rubric*") e aceder aos materiais disponíveis para imprimir ("*printables*").

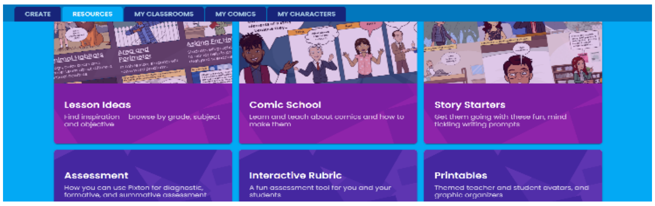


Fig. 3. Separador “*Resources*” (Recursos e Guias)

No separador “*my classrooms*” (fig. 4), o utilizador pode ver e/ou criar a(s) sua(s) turma(s). Importa referir que o docente tem a possibilidade de permitir, ou não, alguns recursos/opções, como por exemplo: a criação de personagens não-binárias, acesso a armas e situações de conflito, acesso a opções/recursos religiosos, etc.

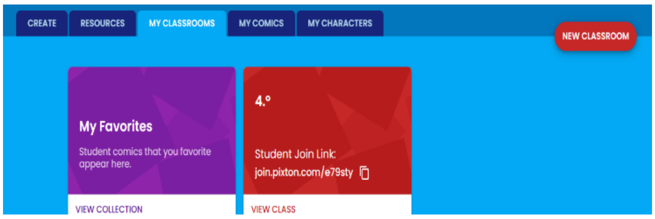


Fig. 4. Separador “*My classrooms*” (turmas)

No separador “my comics” (fig. 5), o utilizador pode criar uma BD (“*create a comic*”), procurar ideias (“*need an idea?*”) e ver as suas criações.

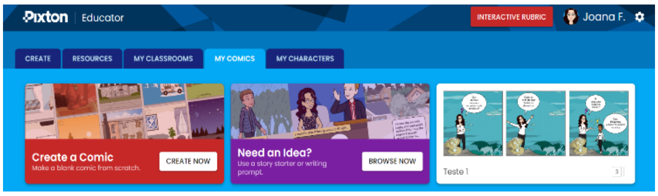


Fig. 5. Separador “*My comics*” (Acesso às criações)

No separador “*my characters*” (fig. 6), o utilizador pode ver, criar e gerir as suas personagens.

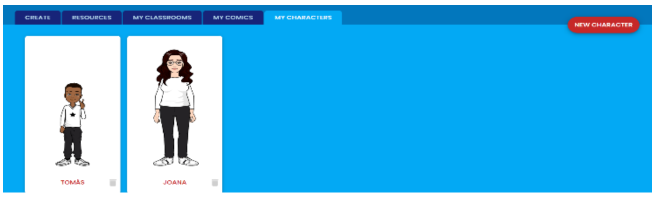


Fig. 6. Separador “*My characters*” (Gestão das personagens)

Relativamente à criação de BD, o utilizador deve ir ao separador “*create*” (criar) e selecionar a opção “*comic maker*” (criador de BD) ou ao separador “*my comics*” (as minhas BD) e selecionar a opção “*create a comic*” (criar uma BD). Ao clicar na opção anterior, o utilizador depara-se com a página inicial de criação de vinhetas (quadradinhos) de BD (fig. 7).

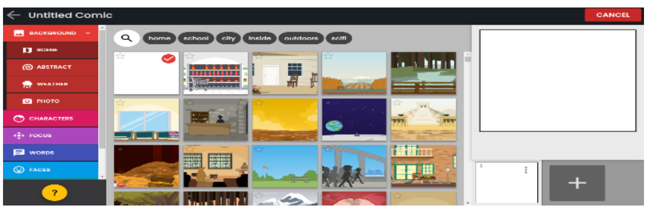


Fig. 7. Página inicial de criação de vinhetas

Terminada a criação da BD basta clicar em “*done*” (feito) – no canto superior direito – para guardar. Caso pretenda editar, depois esta BD, ou alguma vinheta, basta ir às suas BD (“*my comics*”) e clicar em “*edit*”. Caso o utilizador pretenda guardar a BD fora do software, clica em “*download*”. Se desejar imprimir, clica em “*print*” e se decidir partilhar através de um link, clica em “*share*”.

Atendendo à apresentação sumária é importante relembrar que o software *Pixton* é assumido como se tratando de um software educacional visto a sua construção não ter sido feita para fins educativos, mas poder ser utilizado em contexto educativo, tal como se comprova na investigação. Neste sentido, oferece uma diversidade de “instrumentos” que permitem, apagando, arrastando, modificando, gravando, publicando e imprimindo, que se criem BD que variem as personagens, a sua cor da pele, a sua posição, a sua expressão facial, o seu posicionamento, o ambiente onde se encontram, os objetos presentes, as cores destes, entre diversas outras opções. Devido a algumas atualizações, a versão portuguesa já não existe, mas continua a contar com uma versão em inglês, em francês e em espanhol. Apesar de existirem algumas “decorações” pagas, estas não interferem na utilização do software, apenas limitam, ainda que não seja para além do sentido estético e não cause grande interferência, as escolhas do utilizador.

De um modo geral, a potencialidade que o *Pixton* tem para tornar as aulas mais interativas, dinâmicas e atrativas foi o que o tornou recurso da investigação. Para além disto, e considerando tudo o que foi referido anteriormente, acreditamos que permite ao professor captar a atenção dos seus alunos e motivá-los. O facto de ser um software que admite uma fácil adaptação ao objetivo é um aspeto vantajoso. Isto porque o professor pode começar, por exemplo, por criar uma BD onde deixa somente os balões para os alunos preencherem, ou pode até mesmo dar total liberdade aos alunos na sua construção, desde que exista um enquadramento e uma ligação aos objetivos educacionais e respetivos conteúdos. Quer isto dizer que é um software que pode ser caracterizado também de sistema de autor, pois tanto pode ser utilizado para ensinar (quando é o professor a utilizar este recurso para contextualizar situações associadas ao ensino) como para aprender (quando os alunos são requisitados a responder a questões, a preencherem textos «lacunados» ou a serem eles próprios a criarem as suas BD na forma de atividades para os seus colegas). Desta forma, os alunos terão de ter já adquiridos certos conteúdos e podem, deste modo, testar esses seus conhecimentos em forma de uma autoavaliação. Ao mesmo tempo, possibilita que os alunos trabalhem de forma colaborativa com os seus colegas, discutindo quais os conteúdos a introduzirem nas atividades e a corrigirem as respostas obtidas. Este processo poderá promover um maior envolvimento dos alunos no seu processo de aprendizagem tanto individual como colaborativo. Para além destes aspetos, a BD e o software permitem promover várias competências e podem ser trabalhadas em várias áreas. Este recurso também permite que o professor lecione os conteúdos ou os complemente. Assim, permite avaliar os conhecimentos dos seus alunos, através do preenchimento de balões, ou da construção de uma BD relacionada com um determinado tema. Entre outras diversas ideias e modos de exploração.

Em suma, e considerando as potencialidades e ofertas do software *Pixton*, este pode ser uma ferramenta capaz de cativar a atenção dos alunos e trazê-los para a atualidade que passa no envolvimento das tecnologias digitais.

III. Metodologia

A finalidade do estudo é investigar a utilização do software *Pixton*, assumido como software educacional, incluído como recurso numa estratégia de ensino e aprendizagem numa turma do 1.ºCEB. Através desta investigação, pretendemos compreender de que modo as TIC influenciam o processo de ensino e aprendizagem dos alunos, focando o estudo no software *Pixton*. Tratou-se de uma investigação de natureza qualitativa, no âmbito de uma investigação-ação, por ter a intenção de que o investigador consiga um conhecimento mais apropriado da realidade, pois trata-se de um processo cíclico entre investigar, agir e refletir. Pode favorecer a realização de estudos posteriores, que procurem familiarizar os alunos com softwares educativos/educacionais, para que se possam realizar atividades, a fim de se adquirirem aprendizagens, por parte dos alunos, através do uso de recursos digitais. No entanto, este estudo pode não ser suficiente para compreender o fenómeno em causa. Visto esta investigação estar circunscrita a uma dada escola e a uma dada turma, os resultados e as conclusões a retirar não poderão ser generalizados. Por esse motivo, esta investigação poderá ser assim encarada como um estudo de caracter exploratório que será complementado por outras investigações que vierem a ser realizadas neste domínio.

Esta investigação foi realizada no contexto da Prática de Ensino Supervisionada no 1.º CEB (PES 1.ºCEB) numa Escola Básica situada no concelho de Castelo Branco. Os participantes foram os 28 alunos da turma A do 4.º ano. Esta turma era composta por 12 alunos do sexo feminino e 16 alunos do sexo masculino, com idades entre os 9 e os 10 anos. Esta investigação contou ainda com a participação da Orientadora Cooperante (OC) que colaborou durante a PES 1.º CEB e na recolha de informações sobre a temática, e de quatro professores de 1.ºCEB, que permitiram alargar a recolha das opiniões dos docentes. Para a recolha de dados, as técnicas e instrumentos utilizados foram a análise documental, a observação participante e não participante, as notas de campo, os registos fotográficos e a entrevista semiestruturada. Posteriormente, as técnicas utilizadas na análise de dados foram a análise de conteúdo e a triangulação de dados.

IV. Resultados obtidos

D. Sessões de intervenção

A exploração e a implementação das atividades que recorreram ao software *Pixton* foram incluídas nas planificações didáticas, sempre construídas tendo em consideração os Programas e Metas Curriculares, e o PA. Para além disto, as atividades foram sempre planeadas tendo em conta os conteúdos programáticos e os objetivos propostos pela OC. Deste modo, antes de construirmos a Unidade Didática (UD), procurávamos compreender e integrar, sempre que possível, as atividades que envolviam o software *Pixton*, na planificação. A utilização do software *Pixton* na PES 1.ºCEB decorreu em duas sessões, em dias distintos.

As atividades implementadas basearam-se nos seguintes aspetos: explicação dos conteúdos relacionados com a BD; apresentação de atividades; análise da BD «lacunada»; e preenchimento e construção da BD em suporte papel e em suporte digital (no software *Pixton*). De um modo geral, na primeira sessão de implementação os alunos tinham de decifrar algumas frases que permitissem completar os balões e legendas de uma BD «lacunada», permitindo que ficassem com o seguinte resultado (fig. 8):

Fig. 8. Resultado obtido da BD (25 de abril de 1974), com recurso ao software *Pixton*.

Na segunda sessão de intervenção, ainda que o desejo inicial fosse dar mais autonomia aos alunos na utilização do software, tivemos de ter em conta as medidas de segurança impostas e a situação pandémica que nos encontrávamos a enfrentar. Assim, e atendendo que não era possível que cada aluno tivesse acesso a um computador, ou que existissem computadores suficientes para pequenos grupos, a atividade foi pensada e desenvolvida para que pudesse ser implementada em grande grupo. Primeiramente, foi apresentada e analisada a BD «lacunada». Seguidamente, foram convidados a registar no caderno diário, como completariam cada espaço. Depois de todos terem escrito as suas respostas no caderno diário, o desafio era que os alunos partilhassem as suas ideias, possibilitando a que, em grande grupo, se pudesse completar a BD, recorrendo a várias propostas apresentadas pelos diferentes alunos. Neste sentido, à medida que os alunos partilhavam as suas propostas, estas eram escritas no quadro e era construída uma frase, que agrupasse as propostas partilhadas. Caso fosse necessário fazer alguma melhoria, esta era sempre feita em grande grupo e eram sempre ouvidas todas as ideias e opiniões. Com este trabalho, obtivemos o seguinte resultado (fig. 9).

Fig. 9. Resultado obtido da BD (Política dos 5 Rs), com recurso ao software *Pixton*, na versão digital

Importa realçar, que os alunos registaram na BD lacunada impressa, à medida que ia sendo preenchido no software.As sessões de intervenção, ainda que apenas tenham sido possível realizar duas, demonstraram que o software *Pixton* permitiu que os alunos se sentissem motivados e envolvidos para consolidar os conteúdos e para mostrarem que os tinham adquirido. Para além disto, e atendendo à investigação feita e às suas limitações, possibilitou que fosse realizado um trabalho colaborativo, pelo facto de terem sido criados espaços para a partilha e discussão de propostas dos alunos. Com a impressão da BD lacunada, os alunos também podiam ficar com uma versão da BD construída por eles e com um resumo ou uma ligação ao quotidiano. Devido ao vasto currículo que era necessário lecionar e ao pouco tempo para o fazer, não foi possível realizar mais sessões de intervenção. Para além deste normativo, a situação pandémica que nos encontrávamos a enfrentar, não possibilitou que esta investigação fosse realizada como planeado inicialmente. Pois, inicialmente, tinha-se previsto que fossem os alunos a construir uma BD. Desta forma, a implementação do trabalho colaborativo seria evidente e, por essa via, obrigaria a que os alunos dominassem os conteúdos envolvidos nas atividades/ vinhetas que iriam apresentar aos restantes colegas. Neste contexto, pode-se afirmar que teria lugar uma avaliação formativa que daria aos alunos todas as pistas em relação aos conhecimentos que já tinham adquirido e aqueles conteúdos em que necessitavam de mais estudo. Estamos convencidos que se estas atividades pudessem ter sido implementadas iria gerar-se um contexto mais lúdico e menos formal, o que poderia tornar os alunos ainda mais motivados pelo facto de sentirem que estavam a ter um papel mais central. Outro fator que contribuiu neste sentido, foi a escassez de recursos digitais por parte da escola e dos alunos. Contudo, e considerando o estudo realizado, contribuiu para que compreendêssemos que o software *Pixton* se pode apresentar benéfico no processo de ensino e aprendizagem.

E. Entrevistas semiestruturadas

A fim de compreender a opinião dos docentes em relação à importância das TIC em termos pessoais e no contexto educativo, focando, também, nos contributos do software *Pixton* no processo de ensino e aprendizagem dos alunos do 1.ºCEB, foram realizadas cinco entrevistas semiestruturadas: à OC e a quatro docentes do 1.ºCEB. Em relação à formação nas TIC, pudemos concluir que a formação inicial é muito frágil ou inexistente e as docentes sentiram necessidade de realizar formações na área das TIC. No que concerne à utilização das TIC para fins pessoais, as entrevistadas utilizam-nas no seu dia a dia e consideram-nas importantes. Relativamente à utilização das TIC no contexto educativo, também as consideram importantes e utilizam no processo de ensino e aprendizagem. No entanto, não utilizam com a frequência que gostariam por falta de equipamentos e formação. No que diz respeito ao uso do software *Pixton* em contexto educativo, consideram que a sua utilização pode ser vantajosa, motivadora, lúdica, criativa, versátil e adaptável [sistema de autor]. A OC acrescente ainda que a utilização do software poderia ser mais vantajosa se existissem mais recursos digitais.

V. Considerações Finais

Uma vez que a sociedade atual se encontra cada vez mais ligada ao digital, e necessita das TIC para se integrar na sociedade, a educação necessitou de se adaptar, tendo vindo a incluir as TIC no processo de ensino e aprendizagem. Assim, e de forma a promover as TIC, através do software *Pixton*, no contexto de sala de aula, pudemos concluir que o software foi possível ser utilizado no contexto educativo, levando um novo e desconhecido recurso digital para a sala de aula. No que diz respeito à aplicação do software *Pixton* na realização de atividades a partir do uso de recursos digitais, o *Pixton* mostrou-se vantajoso, por permitir a criação de um ambiente motivador e atrativo, e permitiu que os alunos realizassem um trabalho colaborativo, na construção de BD capazes de resumir os conteúdos lecionados, sempre num ambiente onde se evidenciou interação entre os alunos com níveis elevados de motivação. Analisando a utilização do *Pixton* na aquisição das aprendizagens dos alunos no processo de ensino e aprendizagem, podemos afirmar que o software contou com um impacto positivo no processo de ensino e aprendizagem. Para além disto, e por se tratar de um software desconhecido para a turma, permitiu criar um ambiente motivador, lúdico e atrativo, capaz de despertar o interesse dos alunos, enquanto colocavam à prova as suas aprendizagens. Todavia, esta investigação, contou com algumas limitações, nomeadamente a situação pandémica que nos encontrávamos a enfrentar, a falta de equipamento digitais e o currículo extenso. Estes constrangimentos retiraram liberdade aos alunos e impossibilitaram um trabalho mais individualizado e ativo. Assim, recomenda-se que sejam realizadas mais sessões de intervenções, com várias turmas/anos, onde se permita que os alunos tenham mais autonomia na construção de uma história de acordo com o conteúdo trabalhado, e que se construa um livro de BD com os resumos dos conteúdos trabalhados ao longo de todo um ano letivo.

References

[1] J. Ponte, “Tecnologias de informação e comunicação na formação de professores: que desafios?,” in Revista ibero-americana de educação, vol. 24, 2000, pp. 63-90.

[2] P. Dias and R. Brito, “Crianças (0-8) e tecnologias digitais: que mudanças num ano? – Relatório Portugal 2016”, 2017

[3] H. Gil, “As TIC, os nativos digitais e as práticas de ensino supervisionadas: um novo espaço e uma nova oportunidade”, in III conferência internacional – Investigação práticas e contextos em educação, 2014, pp. 89-95.

[4] R. Oliveira, “Informática educativa: dos planos e discursos à sala de aula”, 2010.

[5] P. Faria, “Integração curricular das tecnologias educativas no ensino da língua portuguesa: Um blogue para desenvolver a leitura e a escrita”, in Educação, formação & tecnologias, vol. 1, 2008, pp. 581-600.

[6] F. Sossai, G. Mendes and J. Pacheco, “Currículo e novas tecnologias em tempos de globalização”, in Perspectiva, vol. 27, 2009, pp. 19-46.

[7] V. Kenski, “Educação e tecnologias: o novo ritmo da informação, 2007.

[8] J. Godinho and H. Gil, “A ferramenta digital Web 2.0 - «QR Code» - no 1.º CEB: Utilização em contextos da Prática de Ensino Supervisionada”, in Investigação, Práticas e Contextos em Educação - Livro de atas: VIII conferência internacional, 2019, pp. 5-500.

[9] R. Lima, “A escola que temos e a escola que queremos: O que se passa com a educação? Um olhar sobre as principais preocupações de pais, alunos e professores”, 2017.

[10] A. Trigueiros, “Relevância das TIC para uma aldeia global”, in A escola e as TIC na sociedade do conhecimento, 2013, pp. 127-149.

[11] Direção-Geral da Educação, “Orientações curriculares para as TIC no 1.º ciclo do ensino básico”, 2018.

[12] S. Jucá, “A revelância dos softwares educativos na educação profissional”, in Ciências & cognição, vol. 8, 2006, pp. 22-28.

[13] F. Souza, “A importância da diversidade dos instrumentos avaliativos”, in Revista científica FESA, vol. 1, 2009, pp. 36-46.

[14] C. Klein, “A arte de ensinar utilizando softwares educativos”, 2006.

[15] M. Bento and J. Lencastre, “Utilização de recursos multimédia na educação: inovação ou tradição?”, in Atas do congresso, formação e trabalho docente na sociedade da aprendizagem, 2014, pp. 1032-1045.

[16] S. Ferreira, “O uso de software educativo em ambiente de aprendizagem: Um estudo de caso com alunos do 1º Ciclo do Ensino Básico”, 2009.

[17] H. Pais and F. Candeias, “Avaliações formativa digital”, 2021.

CONTRIBUTOS E POTENCIALIDADES DA APLICAÇÃO DIGITAL WHEELDECIDE NUMA TURMA DO 1.º CEB

Henrique Gil
Age.Comm - Instituto Politécnico de Castelo Branco
Castelo Branco, Portugal
hteixeiragil@ipcb.pt

Rute Mateus
Escola Superior de Educação - Instituto Politécnico de Castelo Branco
Castelo Branco, Portugal
rute.mateus1997@hotmail.com

***Abstract*—Na atualidade, as Tecnologias da Informação e Comunicação (TIC) encontram-se em praticamente todas as áreas de atividade e têm uma importância imprescindível, e assim sendo, a escola não é exceção. O relatório de estágio teve como objetivo investigar se a aplicação digital WheelDecide pode promover o trabalho colaborativo e o processo de avaliação formativa. De modo a compreender esta questão realizámos uma investigação de natureza qualitativa, optando pela investigação-ação no âmbito da Prática de Ensino Supervisionada no 1.º CEB, numa turma de 2.º ano de escolaridade, com 21 alunos. De acordo com a metodologia selecionada foram utilizadas como técnicas e instrumentos de recolha de dados a observação direta/participante, as notas de campo, as entrevistas semiestruturadas à professora titular da turma e a duas docentes que lecionam no 1.º CEB, a aplicação de inquéritos por questionário aos encarregados de educação e o registo fotográfico. No decurso da investigação foram desenvolvidas cinco sessões de intervenção e no decorrer do processo foram recolhidas as diversas opiniões que permitiram realizar a triangulação dos dados obtidos, apurando-se que a utilização a WheelDecide consegue promover o trabalho colaborativo e criar oportunidades para se proceder à avaliação formativa. Neste sentido e tendo em consideração a análise de dados das entrevistas semiestruturadas constatamos que as docentes consideram este recurso com potencialidades, capaz de proporcionar aprendizagens significativas. Já na opinião dos encarregados de educação é possível perceber que a utilização deste recurso digital pode desencadear melhores aprendizagens, criando um ambiente mais motivador, ainda que não seja dispensável a presença e supervisão do professor. Após a triangulação dos dados obtidos é reconhecida a importância da utilização deste recurso pela criação de contextos inovadores que proporcionam aprendizagens mais significativas.**

Keywords*—1.º Ciclo do Ensino Básico; WheelDecide; Trabalho colaborativo; Avaliação formativa; Tecnologias da Informação e Comunicação.

I. INTRODUÇÃO

As tecnologias digitais têm registado uma grande evolução e, como tal, é crucial que a Escola acompanhe essa evolução. Desta forma, decidimos realizar um estudo centrado nas tecnologias digitais pela importância que estas apresentam no processo de ensino-aprendizagem e pelos benefícios no desenvolvimento e aquisição de competências digitais dos alunos envolvidos.

A investigação foi de cariz qualitativo, tratando-se de uma investigação-ação. No decorrer da investigação foi dado especial destaque à importância da utilização das TIC em contexto educativo. No âmbito desta investigação relacionada com as tecnologias digitais, optámos pela utilização da aplicação digital WheelDecide. A seleção desta tecnologia relaciona-se com o facto de ser uma aplicação digital pouco conhecida e explorada em contexto educativo. Por considerarmos que a sua integração em contexto educativo pode motivar e facilitar o processo de ensino-aprendizagem considerámos ainda mais pertinente a seleção deste recurso digital pela possibilidade que oferece poder ser contextualizadas nas diferentes áreas curriculares do 1.º CEB.

Em primeiro lugar, apresentaremos um breve enquadramento teórico sobre as TIC na sociedade e em contexto educativo. De seguida, explicitaremos em que consiste a aplicação digital WheelDecide e como pode ser potenciadora de aprendizagens em contexto educativo desenvolvendo o trabalho colaborativo e permitindo o processo de avaliação formativa. Posteriormente, destacaremos a metodologia utilizada na investigação e, em seguida, destacaremos a recolha e análise dos dados recolhidos. Por fim, apresentaremos as principais conclusões do estudo.

II. AS TIC NA SOCIEDADE E EM CONTEXTO EDUCATIVO

Na atualidade, as Tecnologias da Informação e Comunicação (TIC) encontram-se em praticamente todas as áreas de atividade e têm uma importância imprescindível e, assim sendo, a escola não é exceção. As TIC encontram-se de tal modo enraizadas que já são referenciadas há várias décadas, como podemos constatar pela visão de [8] "(…) já ninguém questiona a necessidade de introduzir as novas tecnologias da informação na escola (…). São consideradas ferramentas que potenciam a vontade de aprender e meios essenciais para ter acesso à informação e promover a aprendizagem." Ao longo do tempo a utilização das TIC continuam a ter tal relevância que de acordo com [1] a tecnologia educativa tem de ser vista e considerada "(…) enquanto conjunto de metodologias, processos, estratégias, ferramentas e instrumentos que podem ser mobilizados para promover o máximo de aprendizagens em todos os alunos (…)."

Estas tecnologias digitais apresentam um papel relevante nas escolas contribuindo para diversas formas de aprendizagem. Recorrendo às tecnologias e às aplicações digitais pretende-se aumentar o interesse e a motivação dos alunos para as atividades apresentadas e para as aprendizagens que se pretende que adquiram. Pois, de um modo geral, as TIC constituem um fator de motivação para os alunos pelo facto dos jovens mostrarem uma grande afinidade e familiarização na utilização de diversos recursos digitais no seu dia a dia. Uma vez que as tecnologias digitais estão bastante presentes no nosso quotidiano é importante referir que ao nível do contexto educativo são inúmeros os softwares educativos criados para despertar a curiosidade dos alunos e para os motivar no aprofundamento de determinados conteúdos e temáticas. De acordo com [6] as aplicações digitais educativas são aquelas em que as crianças "(…) are cognitively active and engage, when learning experiences are meaningful and socially interactive, and when learning is guided by a specific goal."

Numa outra perspetiva, podemos afirmar que sempre que se apresenta o conceito "educativo" se remete diretamente para aspetos e conteúdos trabalhados na escola, na educação formal e não se reflete sobre a possibilidade de desenvolver outras competências. A utilização de um software educativo como recurso na sala de aula pretende facilitar o processo de ensino-aprendizagem. O objetivo não é substituir o professor ou terminar com a forma como se trabalha nas escolas, mas sim, complementar o trabalho que é feito de forma mais criativa, despertando a criatividade e proporcionando um ambiente mais estimulante no sentido de poder proporcionar melhores aprendizagens e aprendizagens mais significativas.

III. TRABALHO COLABORATIVO E AVALIAÇÃO FORMATIVA

Quando entramos numa sala de aula são diversas as diferenças entre os alunos. Tendo em consideração este aspeto, o desenvolvimento de trabalho colaborativo incentiva a que os alunos lidem com as diferenças da melhor forma possível. Ou seja, de diferentes pontos de vista e de diferentes conceções dos colegas de forma a poderem discuti-las e encontrarem pontos convergentes e/ou mais consensuais. O trabalho colaborativo, tal como afirma [2]: "Envolve uma tomada de decisões conjunta e requer tempo, uma negociação cuidadosa, confiança e uma comunicação eficaz (…)".

As tecnologias podem promover o trabalho colaborativo que é um aspeto muito importante no desenvolvimento dos alunos. De outro ponto de vista, podemos ainda considerar que as tecnologias e a utilização de aplicações digitais permitem avaliar conhecimentos adquiridos pelos alunos de uma forma que poderemos designar um pouco diferente da avaliação tradicional. O desenvolvimento do trabalho colaborativo pode conduzir a mudanças de mentalidades e a outras formas de ver uma questão e de perspetivar a mesma. O trabalho colaborativo pode ser um aspeto positivo na forma de aprendizagem, uma vez que as crianças ao falarem com os seus pares podem compreender melhor e de modo mais facilitado determinados conteúdos, de acordo com diferentes pontos de vista. Neste sentido, o trabalho colaborativo deve ser visto como uma prioridade e como um modo de melhoria do processo de ensino e de aprendizagem. Na perspetiva de [9]: "O trabalho colaborativo estrutura-se essencialmente como um processo de trabalho articulado e pensado em conjunto, que permite alcançar melhor os resultados visados, com base no enriquecimento trazido pela interação dinâmica de vários saberes específicos e de vários processos cognitivos.".

A avaliação é inerente ao processo de ensino-aprendizagem, pelo que é essencial compreender em que consiste a avaliação. [5], a avaliação "(…) pode ser definida como um processo sistemático de determinar a extensão em que os objectivos educacionais foram alcançados pelos alunos (…).". De acordo com o Decreto-Lei n.º 139/2012, de 5 de julho, a avaliação "(…) constitui um processo regulador do ensino, orientador do percurso escolar e certificador dos conhecimentos adquiridos e capacidades desenvolvidas pelo aluno." No que diz respeito à avaliação formativa esta funciona como um feedback de regulação para o aluno e para o professor. Através desta avaliação, o aluno consegue ter uma perceção mais concreta dos conteúdos que já domina e dos conteúdos que ainda não estão bem consolidados. No caso do professor, consegue constatar que objetivos foram atingidos, que objetivos foram parcialmente atingidos ou que objetivos ainda não foram atingidos. Após esta avaliação o professor pode mudar as suas metodologias e adaptar critérios sem nunca perder de vista o programa e os objetivos que pretende atingir. Tal como já era afirmado por [3]: a avaliação formativa tem por único fim reconhecer onde e em quê o aluno sente dificuldade e procurar informá-lo. Esta avaliação não se traduz em nota, nem muito menos em scores. Trata-se dum feedback para o aluno e para o professor.

De acordo com a Direção Geral de Educação (DGE), no Decreto-Lei n.º 139/2012, de 5 de julho de 2012, o processo de avaliação formativa entende-se como: "(…)a avaliação formativa é contínua e sistemática e tem função diagnóstica, permitindo ao professor, ao aluno, ao encarregado de educação e a outras pessoas ou entidades legalmente autorizadas obter informação sobre o desenvolvimento das aprendizagens, com vista ao ajustamento de processos e estratégias."

Através de atividades desenvolvidas com recurso à aplicação digital WheelDecide, foi possível realizar trabalho colaborativo, desenvolvendo diversas competências importantes para os alunos. Essas competências relacionam-se fundamentalmente com a melhoria das relações interpessoais, isto porque através do trabalho colaborativo se desenvolve a capacidade de aceitar a opinião dos outros, a troca de experiências e uma negociação. Considerando que no desenvolvimento do trabalho colaborativo existe interação entre os intervenientes é desenvolvido o diálogo, mas também a capacidade de reflexão. Por outro lado, e através dessas mesmas atividades houve a possibilidade de ter consciência de quais os conteúdos que já se encontravam consolidados e quais ainda necessitavam de mais sistematização.

IV. APLICAÇÃO DIGITAL WHEELDECIDE

A aplicação digital WheelDecide consiste numa roleta digital que pode ser utilizada com diversos fins. No caso específico da nossa investigação pretendíamos utilizá-la de forma a conseguir permitir a inclusão de diferentes conteúdos num contexto colaborativo, estimulando-se a interação entre professor-aluno e entre aluno-aluno. Esta aplicação digital apresenta diversas finalidades, ao nível educativo. Assim, podemos utilizar a aplicação digital sempre que desejamos escolher um aluno para responder a uma questão ou se o pretendemos fazer de forma aleatória. Contudo, esta aplicação digital alia a si diversas potencialidades acrescidas que a diferem de uma roleta convencional. Primeiramente e, tratando-se de uma aplicação digital é muito motivadora para os alunos. Apesar disso, é uma roleta temática de conteúdos que pode ser personalizada. Ou seja, significa que pode ser reduzida, aumentada e explorada de acordo com as necessidades e especificidades dos alunos em questão. Por outro lado, o fator aleatório faz com que os alunos permaneçam em constante interação e espectativa. De outro modo, e tendo em conta que os alunos tiveram o privilégio de criar roletas temáticas de conteúdos possibilitou que estes pudessem ser avaliados de modo formativo e colaborativo. A figura 1 apresenta um exemplo de uma roleta de conteúdos:

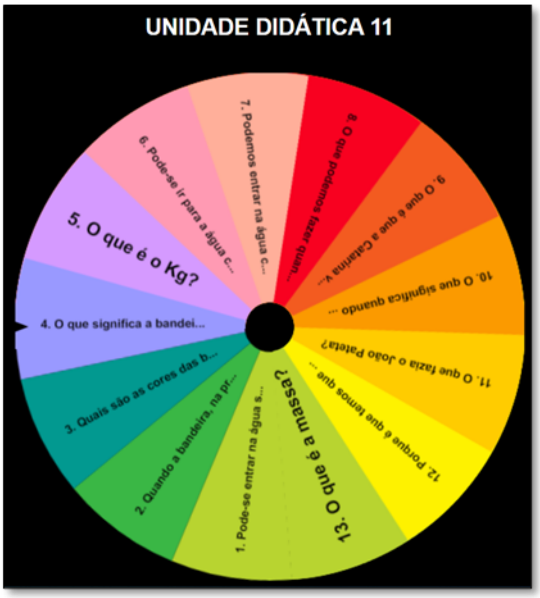


Fig. 1. Exemplo de uma roleta de conteúdos

Com a construção de roletas temáticas de conteúdos os alunos tiveram de mobilizar os seus conhecimentos porque tinham que saber quais as respostas e, consequentemente, saber selecionar os conteúdos. Por fim, e uma vez que as roletas temáticas de conteúdos podem ser contruídas em grupo, é possível desenvolver o trabalho colaborativo. Para a construção da roleta temática de conteúdos há diversas possibilidades de personalização, entre as quais, a escolha de cores que terá a roleta, o que estará escrito em cada umas das secções da mesma e até o tempo de rotação da roleta.

V. Metodologia

A investigação realizou-se no âmbito do Mestrado em Educação Pré-Escolar e Ensino do 1. º Ciclo do Ensino Básico, no âmbito da Unidade Curricular de Prática de Ensino Supervisionada em 1. º Ciclo do Ensino Básico. Para a investigação foi tida em consideração a seguinte questão problema: "Será que a aplicação digital WheelDecide consegue promover o trabalho colaborativo no âmbito do processo de avaliação formativa numa turma do 1.º CEB?". Como forma de dar resposta à questão-problema anteriormente apresentada foram desenhados os seguintes objetivos: incluir as tecnologias digitais em contexto sala de aula; implementar atividades pedagógicas com a aplicação digital WheelDecide; avaliar o impacto da aplicação digital WheelDecide: na promoção do trabalho colaborativo e no processo de avaliação formativa da turma e recolher as opiniões dos professores do 1.º CEB e dos Encarregados de Educação relativamente à utilização de aplicações digitais em contexto sala de aula.

No âmbito de uma investigação de cariz qualitativo considerámos pertinente e selecionámos a investigação-ação. Esta metodologia como o próprio nome indica apresenta dois objetivos principais: por um lado a investigação e por outro lado a ação. Na perspetiva de [7] "(…) podemos definir a investigação-ação como o estudo de uma situação social no sentido de melhorar a qualidade da ação que nela decorre." [7] afirmam ainda que a finalidade própria da investigação-ação é "(…) apoiar os professores e os grupos de professores para lidarem com os desafios e problemas da prática e para adoptarem as inovações de forma reflectida." Ao longo do processo de investigação-ação existem diversas etapas a ser seguidas e trabalhas, nomeadamente: num primeiro ciclo – planificação, ação, observação, reflexão; num segundo ciclo – revisão, ação, observação, reflexão; e assim sucessivamente nos ciclos seguintes.

De acordo com a metodologia selecionada e utilizada foram preferidas como técnicas e instrumentos de recolha de dados a observação direta/participante, as notas de campo, as entrevistas semiestruturadas à professora titular da turma e a duas docentes que lecionam no 1.º CEB, a aplicação de inquéritos por questionário aos encarregados de educação e o registo fotográfico. Após a recolha de dados procedeu-se à sua triangulação.

VI. Sessões de intervenção: análise e discussão dos resultados obtidos

Todas as atividades desenvolvidas, nas cinco sessões realizadas com a aplicação digital WheelDecide encontravam-se inseridas e enquadradas nas unidades didáticas das diversas semanas de implementação e nos conteúdos definidos pela orientadora cooperante. Após cada uma das sessões de intervenção era sempre elaborada uma reflexão pela investigadora com a orientadora cooperante e com o orientador científico de forma a identificar e colmatar fragilidades e assinalar os pontos fortes.

Na primeira sessão de intervenção a principal área curricular envolvida foi o Português. O conteúdo associado a esta sessão relacionava-se com a exploração de um texto onde eram abordados alguns dos perigos da Internet. Nesta perspetiva e antes de trabalhar e explorar o texto, questionámos os alunos sobre o uso da internet no seu quotidiano. Todos os alunos afirmaram utilizar a Internet para diversos fins, nomeadamente ver vídeos no Youtube ou até ouvir músicas. Depois do debate de ideias foram abordados alguns cuidados que devemos ter quando recorremos ao mundo virtual. Tendo como ponto de partida este contexto, os alunos foram informados de que nas aulas seguintes iriamos recorrer ao computador para utilizar uma aplicação digital. Ao saberem desta informação ficaram desde logo muito animados, pois apesar de terem este equipamento em casa não é recorrente o seu uso em contexto educativo. Foi evidente a motivação demonstrada, pelas questões que colocaram, nomeadamente:

P: Vamos mesmo mexer nós no computador?

Esta informação proporcionou bastante entusiasmo nos alunos que, desde logo questionaram:

M: Não podemos usar o computador hoje?
I: Mas o que vamos fazer no computador?

Com base nos comentários dos alunos constatámos que o entusiamo estava bastante presente. Foi muito motivador para nós perceber a receção por parte dos alunos. Apesar de termos consciência de que as tecnologias apresentam uma grande motivação e entusiamo nos alunos não era expectável um interesse e envolvimento tão grande.

Na segunda sessão de intervenção o conteúdo associado relacionava-se com uma atividade de escrita orientada sendo a principal área curricular envolvida o Português. Deste modo, procedeu-se à exploração das questões de orientação para a escrita de um texto. Estas questões foram apresentadas recorrendo à aplicação digital WheelDecide, numa roleta temática de conteúdos criada previamente pela investigadora. As questões a explorar eram: Quem?; O quê?; Onde?; Quando? e Como?.

Para a exploração das questões de orientação para a atividade de escrita orientada foi chamado um aluno ao acaso para vir girar a roleta de conteúdos. Após a exploração da roleta temática de conteúdos, os alunos escreveram um texto recorrendo às respostas que foram registando enquanto utilizámos a roleta. Depois de feita a exploração das questões em grande grupo – turma, cada aluno escreveu o seu texto e no final apresentaram o texto escrito aos colegas.

Nesta segunda sessão alguns alunos tiveram contacto direto com o computador e com a aplicação digital WheelDecide. O facto de ser uma sessão pensada para que os alunos se ambientassem com a aplicação digital em questão foi construída a roleta de conteúdos previamente com as perguntas que orientavam a atividade de escrita. Por seu lado, e uma vez que, apenas alguns alunos puderam interagir diretamente com o computador e com a roleta de conteúdos, foi evidente o desânimo por não poderem utilizar todos o computador para explorar a roleta. Tal facto acabou por resultar numa fragilidade. No final desta sessão, foram vários os comentários ouvidos que demonstraram querer utilizar novamente este recurso:

M.F: Da próxima vez posso ser eu a ir ao computador?

Esta fragilidade foi discutida com a orientadora cooperante de modo a tentar colmatar essa debilidade. Ainda que com esta particularidade menos positiva, a sessão ficou pautada pelo entusiasmo de utilizarem um recurso diferente na sala de aula.

A terceira sessão de intervenção teve como principal área curricular envolvida o Estudo do Meio. O conteúdo associado a esta sessão relacionava-se com o estudo das árvores de folha caduca e árvores de folha perene ou persistente. Neste sentido, procedeu-se inicialmente à exploração e explicitação dos conceitos árvores de folha caduca e árvores de folha perene/persistente recorrendo a duas imagens. Após abordados e explorados estes conceitos foi apresentada uma nova roleta temática de conteúdos relacionada com o estudo dessa mesma temática. No decorrer desta sessão de intervenção com a aplicação digital WheelDecide foram percetíveis diversos comentários por parte dos alunos, nomeadamente:

I.S: Saíram duas árvores repetidas…
M.O: Podemos girar novamente a roleta?

O facto de saírem perguntas repetidas levou a um novo comentário:

M: Podemos escrever sobre outras árvores?

Esta questão surgiu após termos explorado todas as questões presentes na roleta, o que demonstra o interesse dos alunos em participar nas atividades. Por sua vez, e, uma vez que nesta sessão o tempo já estava a escassear não pudemos aceder a este pedido. Contudo, solicitámos aos alunos que pensassem sobre outras árvores que podiam ser inseridas nesta roleta temática de conteúdos.

Esta terceira sessão revelou-se bastante interessante pois os alunos que anteriormente já tinham tido contacto com a roleta mostraram bastante vontade de "ensinar" aos restantes colegas como se utilizava a roleta de conteúdos. Por outro lado, e através da utilização da roleta temática de conteúdos foi promovida a discussão, porque em alguns momentos houve trocas de ideias entres os alunos num contexto colaborativo. No final desta sessão de intervenção a orientadora cooperante mostrou-se particularmente entusiasmada com a utilização da aplicação digital WheelDecide quer pela motivação e interesse dos alunos, quer pela consolidação do conteúdo em questão. Nesta sessão de intervenção foi ainda evidente o entusiasmo dos alunos na utilização desta aplicação digital.

I: Não podemos acrescentar mais árvores para saber se são de folha caduca ou persistente?

Depois deste comentário os alunos foram questionados oralmente sobre outras árvores que poderiam estar na roleta de conteúdos, para além das questões já apresentadas.

Na quarta sessão de intervenção estiveram envolvidas três áreas curriculares: Estudo do Meio, Português e Matemática. Os conteúdos associados a esta sessão relacionavam-se com as propriedades do ar, a interpretação de textos, as medidas de capacidade: litro e o volume.

Esta sessão foi um pouco diferente das sessões anteriores, pois, nesta sessão em concreto, primeiramente trabalhámos todos os conteúdos e só posteriormente foi construída a roleta temática de conteúdos. Esta roleta de conteúdos foi construída pelos alunos após lhes lançarmos o desafio de serem "professores" durante algum tempo. Após lecionados todos os conteúdos os alunos construíram perguntas relacionadas com os conteúdos abordados ao longo da semana. Como consequência, foram relembrados os conteúdos trabalhados no decorrer da semana e cada aluno registou essa informação na folha. Em seguida, desafiámos os alunos a escreverem perguntas relacionadas com esses mesmos conteúdos salientando que se existissem perguntas parecidas ou repetidas seriam corrigidas e melhoradas em turma. Após terem escrito as questões, estas foram lidas em voz alta pelos alunos. Seguidamente houve um debate de ideias sobre quais as questões que seriam mais interessantes para a construção da roleta de conteúdos, atividade que promoveu a negociação e a seleção das questões no seio de um trabalho colaborativo. Neste momento, os alunos foram ainda informados que tinham de saber quais as respostas corretas. Deste modo, houve necessidade de confirmar respostas o que levou à revisão de conteúdos e à consolidação dos mesmos. Neste sentido, e ainda que de forma indireta e informal, foi promovida a avaliação formativa. Esta foi uma atividade muito motivadora para os alunos porque sentiram que teriam alguma responsabilidade e capacidade de decisão. Seguidamente apresentamos algumas das questões propostas pelos alunos:

A: O ar tem peso?
I: Onde vivia o monstro do tempo?
M: O ar ocupa espaço?
M.S: O que acontecia quando o monstro do tempo estava feliz?
M.G: O ar tem cor?

Após a seleção das questões foi proposto que os alunos fossem escrever as questões que elaboraram no computador. Os alunos que nesta sessão foram escrever no computador ficaram muito entusiasmados, algo que é possível verificar pelos seguintes comentários:

I: Posso ajudar a escrever, eu gostei de estar no computador.

M.G: Podíamos escrever mais vezes aqui, é fácil!

Depois de escritas todas as questões foram chamados os alunos que não tinham participado na escrita das perguntas no computador para rodar a roleta de conteúdos construída. Quando saía uma pergunta decidimos que era o autor de cada questão que escolhia qual o colega que respondia e que corrigia esse mesmo colega em caso de necessidade. Este momento da atividade permitiu novamente a existência de trabalho colaborativo, mas também de avaliação formativa. Através da leitura e da resposta das questões foi possível constatar conteúdos que já se encontravam sistematizados e outros que necessitavam de uma maior consolidação. No decorrer desta sessão os alunos mostraram-se bastante motivados. Consideramos que tal reação se ficou a dever ao facto de terem uma participação ainda mais direta com a construção da roleta temática de conteúdos. Apesar dos alunos se mostrarem muito interessados sempre que recorríamos à utilização da aplicação digital WheelDecide, foi notório um sentimento de satisfação maior por terem a responsabilidade integral da construção da roleta temática de conteúdos.

Na quinta e última sessão de intervenção estiveram envolvidas três áreas curriculares: Estudo do Meio, Matemática e Português. Os conteúdos associados a esta sessão relacionavam-se com as regras de segurança junto à água, a grandeza massa e a interpretação de textos. Tal como na sessão anterior, primeiramente, foram relembrados todos os conteúdos abordados ao longo da semana. Os alunos realizaram o registo dessa mesma informação e, em seguida, escreveram perguntas relacionadas com esses mesmos conteúdos salientando que se existissem perguntas parecidas ou repetidas seriam corrigidas e melhoradas em turma. Seguidamente houve um debate de ideias sobre quais as questões que seriam mais interessantes para a construção da roleta de conteúdos, atividade que promoveu a negociação e a seleção das questões, mas também, o trabalho colaborativo.

Seguidamente apresentamos algumas das questões propostas pelos alunos:

C: Pode-se entrar na água sem fazer a digestão?
D: Quais são as cores das bandeiras da praia?
H: O que significa a bandeira azul?
M: Porque é que temos de respeitar as regras na piscina ou na praia?
M. J: O que podemos fazer quando a bandeira está amarela?
M. M: O que é a massa?
M. T: O que significa quando na praia vemos a bandeira ao xadrez?

Tal como na quarta sessão esta foi uma sessão em que foi possível ver a motivação, o interesse e o empenho dos alunos. Nesta sessão foi ainda percetível que a construção integral da roleta temática de conteúdos é aquilo que mais cativa os alunos, tal é possível constatar pelos seguintes comentários:

M: A parte que mais gostei também foi de escrever.

D: Eu gostei de rodar! Fui eu que decidi qual era a pergunta…

Na última sessão foi possível obter uma roleta temática de conteúdos mais completa, como se pode observar nas figura 2. Consideramos que a roleta obtida nesta sessão é mais completa por ter mais questões e por todas elas estarem de facto relacionadas com os conteúdos trabalhados. Por outro lado, consideramos ainda que esta melhoria na construção da roleta temática de conteúdos se fica a dever ao conhecimento que os alunos já adquiriram das sessões anteriores.

Fig. 2. Exemplo de uma roleta de conteúdos utilizada numa sessão prática

VII. Conclusões

Considerando as sessões descritas anteriormente constatamos que a utilização da aplicação digital WheelDecide promoveu a motivação e a interajuda entre os alunos, tendo-se observado trabalho colaborativo.

A utilização dos recursos digitais representa por si só uma mais-valia porque desperta desde o primeiro momento o interesse e a motivação dos alunos para a aprendizagem e para a realização de atividades. Aliando ao computador uma aplicação digital, o processo de aprendizagem acaba por, de certa forma, ficar muito mais facilitado. Por outro lado, este recurso acabou por superar as expectativas iniciais, uma vez que através dele foi possível observar a interajuda entre pares num contexto de trabalho colaborativo. Foi bastante interessante ver a forma como os alunos se envolviam nas atividades e se mantinham motivados por novas atividades recorrendo ao uso da aplicação digital WheelDecide. Importa ainda ressalvar que para a realização das atividades e para a construção da roleta temática de conteúdos os alunos tinham de saber as matérias e quando não estavam seguros das respostas eram, de certa forma, "obrigados" a rever e a consolidar esses mesmos conteúdos. Deste modo, no âmbito de um contexto de avaliação formativa, criaram-se momentos e espaços para a consolidação de aprendizagens e, por consequência, para um maior sucesso educativo.

Fazendo uma retrospetiva das sessões de intervenção consideramos que embora tenha sido muito importante num primeiro momento levar a roleta temática de conteúdos pronta a utilizar, foi muito mais interessante para os alunos a construção integral da roleta com a intervenção direta dos alunos. A interação dos alunos com o computador manifestou-se originadora de um maior dinamismo e envolvimento nas próprias aulas ao lhes ser conferida uma autoridade e uma responsabilidade em termos de tomada de decisão e de iniciativa.

De acordo com a análise de conteúdo realizada às entrevistas semiestruturadas podemos afirmar que as docentes entrevistadas consideraram pertinente e interessante a utilização da aplicação digital WheelDecide em contexto educativo. Contudo, constatou-se que existem algumas "barreiras" que dificultam a utilização destes recursos. Tais entraves relacionam-se com a falta de equipamentos e de condições tecnológicas nas escolas. Percebemos ainda que nenhuma das três docentes conhecia a aplicação digital WheelDecide, pelo que se teve que fazer uma demonstração prática da aplicação digital. Através da análise de conteúdo foi possível verificar que as docentes entrevistadas consideram que com recurso à aplicação digital WheelDecide a aprendizagem se torna mais atrativa, dinâmica e capaz de motivar e captar a atenção dos alunos.

De acordo com os dados obtidos através dos inquéritos por questionário realizados aos pais/encarregados de educação entendemos que a maioria considera as tecnologias muito importantes e capazes de tornar as atividades mais motivadoras, lúdicas e apelativas. Por seu lado, é percetível que não colocam o papel do professor em causa, uma vez que acreditam que as tecnologias não poderão substituir o professor. Os inquiridos apesar de também não conhecerem a aplicação digital WheelDecide acreditam que pode funcionar como elemento lúdico na sala de aula, tanto do agrado dos seus educandos, o que promove um contexto educativo que os motiva a aprenderem.

Sistematizando e concluindo, podemos afirmar que a inclusão das tecnologias digitais no 1.º CEB é importante e essencial. Os alunos nasceram numa era digital e, como tal, possuem uma forte atração pelas tecnologias: nativos digitais. Desta forma, é essencial desenvolver competências digitais nos alunos para que façam um uso consciente das TIC. A integração do trabalho colaborativo e da avaliação formativa, as TIC e a aplicação digital WheelDecide permitem criar um ambiente motivador, inovador e estimulante o que facilita a aquisição de aprendizagens nos alunos. Deste modo, os alunos desenvolvem competências digitais, mas também competências cognitivas para uma integração social mais plena.

Referências

[1] Alves, J. and Cabral, I. No regresso à escola – Reimaginar e praticar uma gramática generativa e tranformacional, 2021.
https://www.fep.porto.ucp.pt/sites/default/files/files/FEP/SAME/%20EBOOK_mar%C3%A7o%2021_VF.pdf

[2] Day, C. Desenvolvimento Profissional de Professores: os Desafios da aprendizagem Permanente. Porto: Porto Editora, 2001.

[3] De Landsheere, G.. Avaliação contínua e exames: noções de docimologia. Coimbra: Almedina, 1979.

[4] Decreto-Lei n.º 139/2012. Diário da República n.º 129/2012 de 5 de agosto – I série. Lisboa: Ministério da Educação

[5] Domingos, A., Neves, I., and Galhardo, L. *Uma forma de estruturar o ensino e a aprendizagem.* (3ª edição). Lisboa: Livros Horizonte, 1987.

[6] Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in "educational" apps lessons from the science of learning. Psychological Science in the Public Interest, v.16(1), (p.3-34). https://www.academia.edu/25362995/Putting_education_in_educational_apps_lessons_from_the_science_of_learning

[7] Máximo-Esteves, L.. *Visão Panorâmica da Investigação-Acção.* Porto: Porto Editora, 2008.

[8] Miranda, G. *As novas tecnologias e a inovação de práticas educativas.* Leituras. Inovação, nº1 (p. 85-92), 1997. Lisboa: Revista da Biblioteca Nacional.
https://comum.rcaap.pt/bitstream/10400.26/6194/1/Helga%20Vieira.pdf

[9] Roldão, M. C. "Colaborar é preciso – Questões de qualidade e eficácia no trabalho dos professores". Revista Noésis, n.º 71 Edições DGIDC. Lisboa. 2007, pp. 24-29

Hacia una propuesta para la medición de la calidad en uso de sistemas CSCL para el aprendizaje de la programación: el caso de estudio de COLLECE 2.0

Rafael Duque
Departamento de Matemáticas, Estadística y Computación Universidad de Cantabria Santander, España
rafael.duque@unican.es

Miguel Ángel Redondo Departamento de Tecnologías y Sistemas de Información Universidad de Castilla-La Mancha Ciudad Real, España
miguel.redondo@uclm.es

Manuel Ortega
Departamento de Tecnologías y Sistemas de Información Universidad de Castilla-La Mancha Ciudad Real, España manuel.ortega@uclm.es

Sergio Salomón
Departamento de Inteligencia Artificial Axpe Consulting
Maliaño, España
ssalomon@axpe.com

Ana Isabel Molina Departamento de Tecnologías y Sistemas de Información Universidad de Castilla-La Mancha Ciudad Real, España
anaisabel.molina@uclm.es

***Abstract*— La programación de computadores es una habilidad cada vez más demandada por las empresas en la actual era digital ya que permite construir soluciones tecnológicas frente a problemas complejos. En un entorno profesional, los programadores habitualmente colaboran en proyectos para construir programas que deben satisfacer un conjunto de requisitos concretos. Los sistemas CSCL (Computer-Supported Collaborative Learning) pueden ser especialmente útiles para facilitar la enseñanza y el aprendizaje de la programación, ya que reproducen ese contexto profesional de trabajo en equipo. La calidad de la experiencia del aprendizaje con sistemas CSCL depende de varios factores, como, por ejemplo, el diseño y la implementación del sistema, la adecuación de las tareas planteadas a los estudiantes, la configuración del grupo de trabajo y la tutorización recibida. Este trabajo aborda el problema de medir la calidad en uso de los sistemas CSCL que dan soporte al proceso de aprendizaje de la programación. Para ello se propone un conjunto de medidas de calidad en uso y se analiza cómo calcularlas automáticamente utilizando el soporte de FAQuiS (Framework for Assessing Quality-in-use of Software), un framework basado en modelos para evaluar las características y subcaracterísticas de calidad en uso recogidas en la norma ISO 25010:2011. El artículo incluye un estudio de la aplicabilidad de esta propuesta en COLLECE 2.0, un sistema CSCL distribuido síncrono para el aprendizaje de la programación.**

Keywords—programación de computadores, calidad en uso del software, aprendizaje colaborativo soportado por computador.

I. Introducción y Motivación

La programación de computadores implica la generación de instrucciones que la máquina puede procesar para realizar tareas específicas. La actual era digital hace que la demanda de trabajadores con formación en el ámbito de la programación de computadores sea cada vez mayor. En un entorno profesional, es común que se trabaje de forma colaborativa para desarrollar programas que cumplan un conjunto de requisitos específicos. Los sistemas CSCL (Computer-Supported Collaborative Learning) son entornos de aprendizaje que utilizan tecnología informática para apoyar la colaboración entre estudiantes en actividades educativas.

Para facilitar los procesos de enseñanza/aprendizaje de la programación de computadores, los sistemas CSCL pueden considerarse un instrumento especialmente útil en la medida que reproducen el contexto profesional en el que varios programadores participan en un mismo proceso de trabajo [1].

Los sistemas CSCL para el aprendizaje de la programación proporcionan a los estudiantes un entorno de aprendizaje interactivo que les permite trabajar en equipo en tiempo real, independientemente de su ubicación física, compartir conocimientos y recibir retroalimentación de sus compañeros y profesores. Estos sistemas pueden ofrecer variedad de recursos y herramientas como, por ejemplo, tutoriales, ejemplos de código fuente y editores compartidos. Además, los mencionados recursos y herramientas facilitan que la enseñanza/aprendizaje de la programación pueda llevarse a cabo siguiendo un paradigma basado en problemas [2]. En este paradigma los alumnos trabajan en equipo para abordar un problema que implica identificar una solución que luego deben implementar mediante la escritura del código fuente y verificarla mediante la ejecución del programa.

La calidad de la experiencia del aprendizaje con sistemas CSCL puede variar ampliamente, dependiendo de factores como el diseño y la implementación del sistema, la adecuación de las tareas propuestas a los estudiantes, la configuración del grupo de trabajo, dificultades para orquestar la colaboración o la tutorización para construir la solución. Algunas de las fuentes de información que pueden utilizarse para evaluar automáticamente el proceso de trabajo de los alumnos son las interacciones para editar el código [3], los resultados de la ejecución del programa [4], los errores de compilación [5] o métricas de calidad del código [6].

En este punto surge el reto de establecer mediciones estandarizadas de la experiencia de los alumnos como usuarios de sistemas CSCL para el aprendizaje de la programación. Este trabajo aborda este reto a través de una propuesta basada en el framework FAQuiS (Framework for Assessing Quality-in-use of Software) [7] y en la norma ISO 25010:2011 [8] que introduce el concepto de calidad en uso como el grado en que un producto o sistema puede ser

utilizado por usuarios específicos para satisfacer sus necesidades y lograr objetivos específicos con efectividad, eficiencia, sin riesgos y con satisfacción en contextos específicos de uso. La norma ISO 25010:2011 define un modelo de calidad en uso con un conjunto de características y subcaracterísticas del software que facilitan un marco genérico de evaluación. FAQuiS integra un soporte computacional para calcular un conjunto de medidas de la calidad en uso que cuantifiquen las características y sub- características de la norma ISO 25010:2011. El objetivo principal de este trabajo es estudiar la factibilidad de usar el soporte de FAQuiS para medir la calidad en uso de sistemas

CSCL que dan soporte al aprendizaje de la programación. El artículo incluye un estudio de la aplicabilidad de este modelo de evaluación de la calidad en uso utilizando COLLECE 2.0 [9], un sistema CSCL distribuido síncrono para el aprendizaje de la programación.

El artículo incluye 3 secciones adicionales. La Sección 2 presenta nuestra propuesta para medir las características y sub-características de la norma ISO 25010:2011 en sistemas CSCL de soporte a la programación. La Sección 3 describe un caso de estudio en el que se estudiará la aplicabilidad de la propuesta al sistema COLLECE 2.0. La sección 4 analiza las conclusiones del trabajo realizado y las nuevas líneas de investigación que se acometerán en el futuro.

II. Medición De La Calidad En Uso Basada En Modelos Y Archivos De Log

En un trabajo anterior [7] se describió FAQuiS (Framework for Assessing Quality-in-use of Software), un marco de trabajo para calcular medidas de calidad en uso. FAQuiS no utiliza cuestionarios ni entrevistas con usuarios, pero permite complementar estos métodos con un soporte computacional que automatice la medición de calidad en uso procesando archivos de log y los siguientes tres modelos computacionales: (i) modelo de tareas, (ii) modelo de contexto, (iii) modelo de usuario.

El **modelo de tareas** de FAQuiS (ver Fig. 1) se basa en los siguientes conceptos:

- Tarea: Un proceso que permite al usuario alcanzar algún objetivo con el soporte del sistema. Las tareas se categorizan en cuatro tipo [10]: (i) *tareas de usuario*, son realizadas exclusivamente por el usuario sin interactuar con el sistema; (ii) *tareas cognitivas*, son responsabilidad exclusiva del usuario, quien no entra en contacto con el sistema, (iii) *tareas del sistema*, realizadas por la propia aplicación y no requieren de la intervención directa del usuario; (iv) *tareas interactivas*, implican una participación activa por parte del usuario interactuando con el sistema; (v) *tareas abstractas*, se descomponen en un conjunto de subtareas más pequeñas y específicas para facilitar su ejecución y seguimiento.
- Artefacto: Se refiere a los productos, resultados o salidas que los usuarios producen al realizar una tarea utilizando un sistema informático (por ejemplo código fuente, resultado de compilaciones o ejecuciones).
- Acción del usuario: Unidad de interacción del usuario con el sistema, que se almacena en un repositorio de log. Cada acción se clasifica de esta manera [11]: *acción cognitiva*, interactúa con un artefacto pero no altera su estado; *acción comunicativa*, permite el intercambio de mensajes entre usuarios (envío de mensajes a través de chat, foros, correo electrónico, etc.); *acción instrumental*, modifica un artefacto en construcción (por ejemplo, cambios en el código fuente); *acción basada en protocolos*, permite coordinar el proceso colaborativo sin establecer diálogo entre usuarios (solicitud de acceso a un editor compartido, votación sobre una propuesta, etc.).

Además, cada acción puede tener algún riesgo asociado (económico, sanitario, etc.) cuya frecuencia debe estimarse y cuantificarse cómo el sistema mitiga su impacto. Las acciones del usuario permiten al usuario interactuar con el sistema a través de un paradigma de interacción (computación ubicua, realidad aumentada/virtual, etc.).

El **modelo de contexto** (ver Fig. 1) incluye información como la ubicación del usuario, las relaciones sociales que mantiene, si establece una colaboración síncrona o asíncrona. Por último, el modelo de contexto incluye una dimensión tecnológica que especifica el soporte software y hardware del que dispone el usuario.

El **modelo de usuario** (ver Fig. 1.) representa información sobre el perfil de la persona que interactúa con el sistema (rango de edad, género, nacionalidad, etc.), intereses en cierto tipo de tareas, rol (alumno, profesor, etc.) y otros rasgos que pueden influir en la interacción con el sistema (estilo de aprendizaje, conocimientos en relación a la programación, etc.). Además, se establece una especificación de las habilidades técnicas e idiomáticas del usuario.

El **archivo de log** es un repositorio de acciones que ejecuta el usuario o el sistema. Este archivo incluye un identificador de las acciones recogidas en el modelo de tareas que se ejecutan, quién las realiza, cuándo se llevan a cabo y el espacio del sistema que soportan dichas acciones. Este espacio puede ser cualquier elemento de interfaz de usuario definido en el sistema.

FAQuiS genera un conjunto de mediciones asociadas a cada una de las características y sub-características de la norma ISO 25010:2011. Esta norma define concretamente las siguientes cinco características del software asociadas a la calidad en uso: efectividad, eficiencia, mitigación de riesgos, satisfacción y cobertura de contexto.

La característica de efectividad se relaciona, según la norma ISO 25010:2011, con la precisión y completitud con la que los usuarios alcanzan los objetivos especificados. Por tanto, se mide mediante el número de tareas finalizadas exitosamente, la calidad de los resultados de las acciones instrumentales ejecutadas y la concordancia entre el comportamiento de cada usuario y las secuencias de acciones especificadas en el modelo de tareas para alcanzar dichos objetivos.

Según la norma ISO 25010:2011, la eficiencia trata de los recursos empleados para alcanzar objetivos. La medición de recursos se realiza cuantificando la cantidad de tiempo para completar las tareas, así como el número de acciones y espacios empleados.

La característica de mitigación de riesgos se define en la norma ISO 25010:2011 como el grado en el cual un sistema mitiga el riesgo potencial para el estatus económico, la vida humana, la salud o el medioambiente. Las medidas de calidad en uso asociadas a esta característica cuantifican las respuestas del sistema para mitigarlos.

La característica de satisfacción se define como el grado en el cual se satisfacen las necesidades del usuario al emplear un sistema en un contexto de uso específico. Esta característica se representa en el modelo de calidad ISO 25010:2011 mediante las siguientes sub-características:

- Utilidad. Es el grado en que un usuario está satisfecho al percibir que logra sus objetivos de forma pragmática, lo cual incluye los resultados y las consecuencias del uso del sistema. Las medidas asociadas evalúan en qué medida el usuario encuentra útil las acciones y espacios disponibles en el sistema para alcanzar sus objetivos.
- Confianza. Es el grado en el que un usuario, u otro stakeholder, tiene confianza en que un producto o sistema se comportará como se espera que lo haga. Estas medidas evalúan que el usuario ejecuta acciones asociadas a los riesgos y respuestas de otros colaboradores ya que confía en una respuesta satisfactoria por parte del sistema y de los otros participantes.
- Placer. Es el grado en que el usuario siente una experiencia placentera al satisfacer sus requisitos. Las medidas de esta sub-característica evalúan si la persona adquiere nuevas capacidades respecto a las establecidas inicialmente en el modelo de usuario tras el uso del sistema en distintas sesiones de trabajo.
- Comodidad: Grado en que el usuario está satisfecho con la comodidad física del dispositivo. Estas medidas evalúan la densidad de trabajo de cada espacio y la utilización de paradigmas de interacción basados en acciones implícitas y Realidad Aumentada/Virtual que pueden resultar más cómodos al usuario.

La cobertura del contexto define el grado en el cual un sistema se puede usar cumpliendo el resto de las características (efectividad, eficiencia, mitigación de riesgos y satisfacción) en relación al contexto de uso. La norma 25010:2011 define dos sub-características para la cobertura del contexto: cobertura y flexibilidad. La cobertura implica que la calidad en uso se evalúa en un conjunto de contextos de uso que estaban previstos. La flexibilidad implica que el sistema se utiliza por parte de los usuarios en contextos que inicialmente no estaban contemplados.

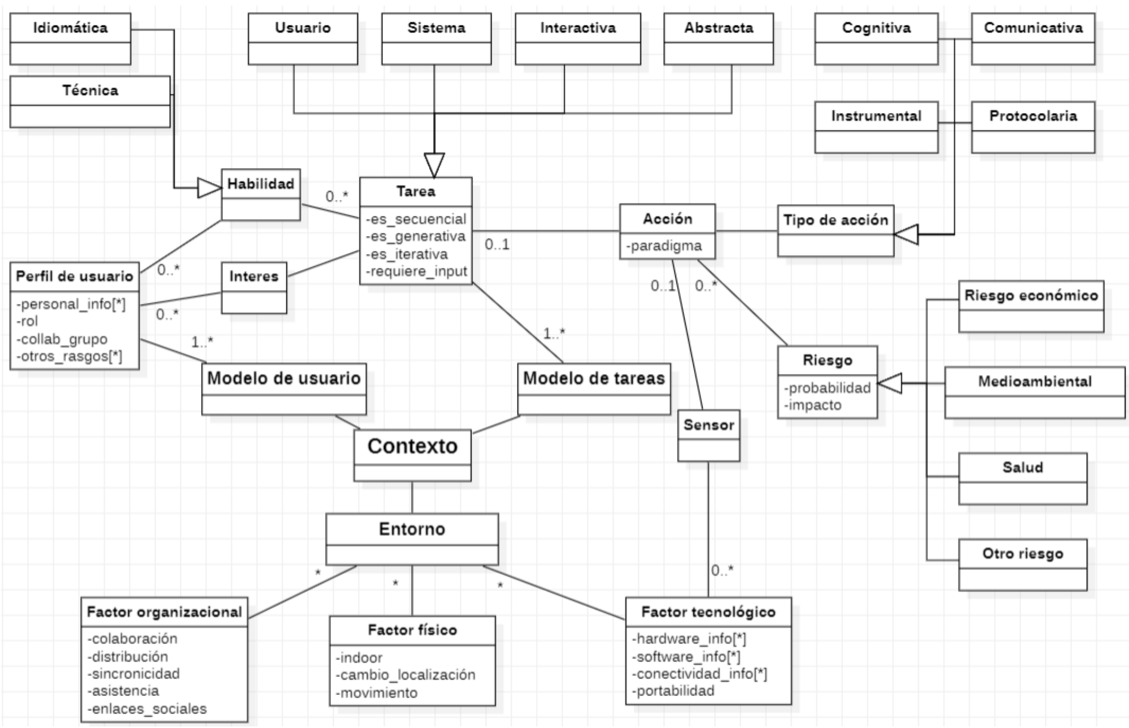


Fig. 1. Metamodelo de FAQuiS

III. CASO DE ESTUDIO: COLLECE 2.0

COLLECE 2.0 (COLLaborative Edition, Compilation and Execution of programs) es un plugin de Eclipse para la programación en grupo, que cuenta con una interfaz de usuario personalizable [9]. Esta interfaz (ver Fig. 2) incluye un árbol de archivos del proyecto, un panel de usuarios conectados, tele-cursores para identificar quién está editando y en qué parte del código lo está haciendo; un editor de código compartido; funcionalidades para el bloqueo de regiones del código para que un alumno pueda prohibir modificaciones de un fragmento de código a otros compañeros; un panel de control de regiones bloqueadas para dar a conocer qué código quedó bloqueado y quién los restringió; chat; y, el enunciado del problema a resolver. Todos estos elementos están diseñados para permitir la colaboración distribuida síncrona de los alumnos para la resolución de problemas en el ámbito de la programación de computadores. Además, COLLECE

2.0 utiliza sistemas de control de versiones para mantener el estado persistente de los proyectos de código asociados a las sesiones.

COLLECE 2.0 también dispone de un espacio que se apoya en el paradigma de Realidad Aumenta (RA) en el que los alumnos pueden visualizar el comportamiento del programa que construyen mediante la notación ANGELA (notAtioN of road siGns to facilitatE the Learning of progrAmming), basada en una metáfora de carreteras y señales de tráfico representadas por gráficos en 3D [12]. Estas representaciones permiten visualizar de manera intuitiva el flujo de ejecución de un programa, ya que los alumnos están familiarizados con estas carreteras y señales en su vida cotidiana. Dichas visualizaciones gráficas pueden generarse automáticamente a partir del código fuente de los programas. La notación ANGELA permite la visualización tanto estática como dinámica de los algoritmos implementados. En el caso de la visualización estática, se busca facilitar la comprensión de las sentencias que componen el programa. Por otro lado, la visualización dinámica permite seguir la ejecución del programa, funcionando como un simulador de la traza del programa.

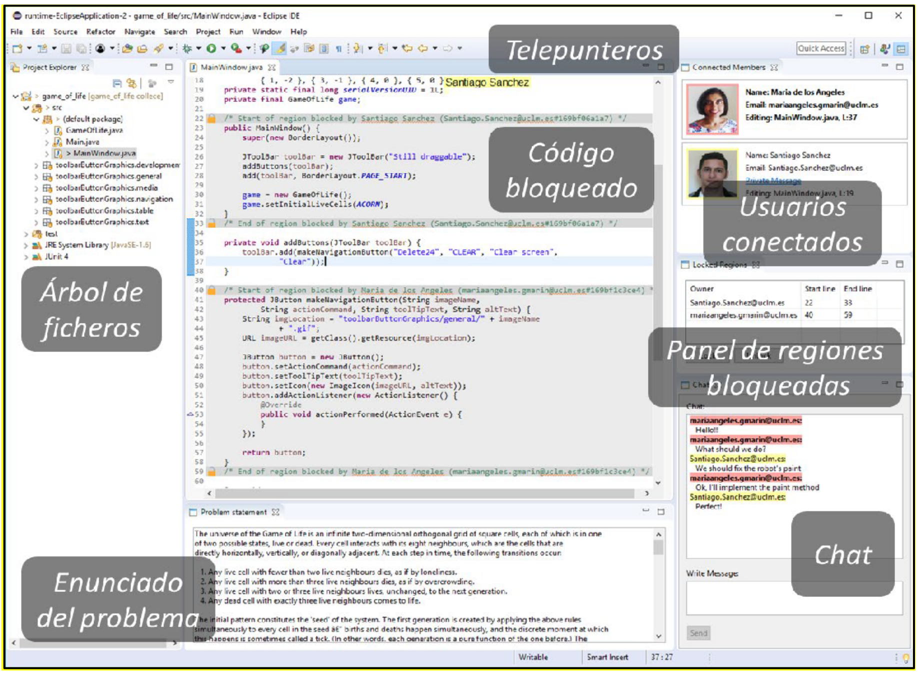


Fig. 2. Interfaz de usuario de COLLECE 2.0

La Tabla I sintetiza cómo las acciones recogidas en archivo de log y el procesamiento de los tres modelos manejados por FAQuiS (modelo de tareas, modelo de contexto y modelo de usuario) permiten evaluar la calidad en uso de COLLECE 2.0 como instrumento de aprendizaje de la programación mediante un enfoque basado en problemas. La Tabla I también muestra algunas intervenciones para solucionar problemas identificados por las mediciones de la calidad en uso del sistema.

La eficacia del proceso de resolución de problemas se mide a través del impacto que tienen las acciones instrumentales en el editor compartido ya que son las que permiten construir un artefacto que resuelva el problema planteado por el sistema, los resultados obtenidos en la consola tras ejecutar acciones de compilación y ejecución, y el grado de seguimiento de los patrones especificados en el modelo de tareas (ver Tabla I). Las intervenciones para corregir deficiencias en la eficacia incluyen sugerencias para mejorar el código, invitar a compilar y ejecutar el programa, rediseñar el sistema para adaptarlo a los patrones de comportamiento de los usuarios.

Las medidas relacionadas con la eficiencia (ver Tabla I) computan la cantidad de tiempo que emplea el alumno en resolver el problema interactuando y ejecutando interacciones en todos los espacios del sistema. De forma más específica, se identifica el editor y la consola de COLLECE

2.0 que usa el alumno y los artefactos que genera. Ello facilita mecanismos de intervención para sugerir al alumno una mayor rapidez y adaptar la complejidad del problema.

La medición de la mitigación de riesgos se realiza en función de lo indicado en el modelo de tareas donde se indican aquellas acciones que podría implicar algún peligro. En este caso se computan las acciones del sistema que de forma exitosa impiden modificar un fragmento del código fuente que fue bloqueado por otro alumno (ver Tabla I).

Para cada una de las sub-características de satisfacción (utilidad, confianza, placer, comodidad) se establece medidas específicas. Así, las medidas de utilidad (ver Tabla I) procesan todas las acciones del repositorio de log para identificar aquellas de las contempladas en el modelo de tareas que no son ejecutadas (acciones de compilación, ejecución, envío de mensajes en el chat, etc.) y aquellos espacios del sistema (consola, panel de bloqueo de regiones, etc.) poco utilizados. La idea es utilizar el valor de estas medidas para intervenir en el proceso de colaboración con tutoriales que muestren cómo aprovechar espacios poco utilizados. Finalmente, se contempla la posibilidad de rediseñar el sistema para ofrecer espacios de mayor utilidad.

TABLE I. MEDICIÓN DE LA CALIDAD EN USO EN COLLECE 2.0

Características y sub-características del ISO 25010:2011	Descripción de las medidas propuestas en FAQuiS	Fuente de información	Mecanismos de intervención
Efectividad	Porcentaje de problemas resueltos satisfactoriamente.	Editor y consola	Sugerencias de mejora en el código fuente
	Número de artefactos generados satisfactoriamente durante el proceso de trabajo.		Sugerencias para compilar y ejecutar el código
	Similitud entre los patrones de interacción del usuario y los del modelo de tareas.	Todos los espacios del sistema y modelo de tareas	Rediseño del sistema para adaptarlo a los patrones de comportamiento del usuario
Eficiencia	Número de espacios usados.	Todos los espacios del sistema	Adaptar la dificultad del problema. Sugerencias para incrementar la cantidad de trabajo.
	Tiempo para completar tareas.		
	Número de acciones ejecutadas.		
	Acciones ejecutadas por unidad de tiempo.		
	Número de tareas completadas.	Editor y consola	
	Artefactos generados por unidad de tiempo.	Editor	
Mitigación de riesgos	Acciones del sistema que impiden modificar código fuente bloqueado	Ediciones del usuario en el código bloqueado	Rediseñar el mecanismo de bloqueo
Utilidad	Número de tareas que incluyen acciones con riesgos o de tipo instrumental y se repiten en diferentes sesiones.	Editor y modelo de tareas	Tutoriales de uso del sistema. Rediseñar el sistema.
	Patrones con una respuesta exitosa de interacción RA	Espacio RA y modelo de tareas	
	Porcentaje de tareas concluidas.	Todos los espacios y modelo de tareas	
	Porcentaje de acciones utilizadas.		
	Porcentaje de espacios utilizados.		
	Porcentaje de acciones del usuario respecto aquellas que implican feedback de ayuda por parte del sistema.	Consola y RA	
	Porcentaje de tareas realizadas con éxito por el usuario con soporte del sistema	Consola	
	Porcentaje de tareas realizadas con éxito por el usuario con soporte protocolario	Bloqueo de código	
Confianza	Número de tareas asociadas a riesgos y que el usuario evita ejecutar.		Sugerencia de uso de la funcionalidad para bloqueo de código
	Acciones asociadas a riesgos y que el usuario ejecuta repetidamente.		
	Tiempos ejecutando tareas asociadas a riesgos.		
	Patrones de acciones que no siguen la secuencia de acciones esperada debido a una respuesta inesperada del sistema.	Todos los elementos del sistema y modelo de tareas	Rediseñar el sistema
	Porcentaje de tareas terminadas respecto empezadas en todas las sesiones de trabajo.		Adaptar dificultad del problema
	Acciones ejecutadas que requieren una respuesta de otro usuario.	Chat	Modificar composición del grupo de trabajo
	Tiempo dedicado a acciones que requieren una respuesta de otro usuario.	Chat	
	Número de acciones en el paradigma RA	Espacio RA	Sugerencia para usar el espacio RA
	Tiempo dedicado a interacciones RA		Rediseñar RA
Placer	Problemas resueltos con éxito que requieren nuevas habilidades	Modelo de usuario, todos los espacios del sistema y modelo de tareas	Adaptar el problema
	Variación en el tiempo de ejecución, es decir en diferentes sesiones, de las tareas que demandan nuevas habilidades.		
	Tendencia a reanudar sesiones de trabajo interrumpidas.	Todos los espacios del sistema	Recordatorio de trabajo pendiente. Adaptar el problema.
Comodidad	Densidad de trabajo en cada espacio	Modelo de tareas	Rediseñar el sistema
	Grado de interacciones RA		
Completitud	Las anteriores medidas por cada contexto de uso previsto		
Flexibilidad	Las anteriores medidas (excepto completitud) por cada contexto de uso no previsto		

La confianza del usuario en el sistema se mide a través de un conjunto de valores que buscan detectar si el alumno carece de respuestas por parte de los compañeros en el chat, rehúye ejecutar acciones protocolarias para bloquear código, no culmina la resolución de problemas que inició de alguna sesión de trabajo previa o no hace uso del paradigma de Realidad Aumentada (ver Tabla I). Ello puede indicar que el alumno no tiene confianza en el funcionamiento del sistema y sería necesario establecer mecanismos de intervención como, por ejemplo, modificar la composición del grupo de trabajo (ver Tabla I).

La sub-característica de placer tiene asociadas medidas (ver Tabla I) que se apoyan en el enunciado del problema y en el modelo del usuario para cuantificar en qué medida el proceso de colaboración le permite al alumno adquirir nuevas habilidades. Así, estas medidas cuantifican si el alumno tiene la capacidad de resolver problemas que le demandan nuevas habilidades y ello lo hace en sesiones de trabajo que cada vez le demandan menos esfuerzo ya que consolida las competencias requeridas. La principal medida de intervención si se detectan deficiencias en este ámbito es adaptar el problema para facilitar al aprendizaje del alumno y la consecución de competencias.

Las medidas de comodidad (ver Tabla I) están relacionadas con la cantidad de acciones que soporta un mismo espacio de la interfaz y pueden dificultar su utilización. También se considera el empleo del paradigma de Realidad Aumentada estimando que este le puede resultar al alumno más cómodo para la realización de sus tareas. El principal mecanismo de intervención para mejorar la comodidad es rediseñar el sistema en caso de que se detecten deficiencias en los valores de estas medidas.

La completitud es una sub-característica de la cobertura del contexto que es cuantificada a través del resto de medidas para conocer si los cambios en el modelo de contexto (la colaboración es síncrona o asíncrona, composición del grupo de trabajo, etc.) influye en el resto de las características de calidad en uso (ver Tabla I). La flexibilidad aplica las métricas ya calculadas para las otras características de calidad en uso para analizar situaciones que inicialmente no fueron identificados en el modelo del contexto (ver Tabla I).

IV. Conclusiones

Este artículo ha abordado la problemática de evaluar los procesos de resolución colaborativa de problemas en el ámbito de la programación soportada por sistemas CSCL. Esta evaluación debe tener en cuenta diversos aspectos como, por ejemplo, la adecuación de la formación de los grupos de trabajo, el soporte ofrecido por el sistema CSCL, las aportaciones de cada miembro del grupo o la calidad de los resultados finales. Con el objetivo de facilitar un modelo de evaluación estandarizado se ha presentado una propuesta basada en FAQuiS, un framework basado en modelos, para generar un conjunto de medidas de calidad en uso que cuantifican las características y sub-características de la norma ISO 25010:2011. Como caso de estudio, se ha analizado la aplicabilidad de este modelo de evaluación a COLLECE 2.0, un sistema CSCL distribuido síncrono para el aprendizaje de la programación. Este caso de estudio ha mostrado cómo la información recogida en archivos de log y en los modelos procesados por FAQuiS permite cuantificar las características

y sub-características de la norma ISO 25010:2011. Ello abre la puerta a realizar evaluaciones estandarizadas de la calidad en uso de los sistemas CSCL que ofrecen soporte al proceso de aprendizaje de la programación.

En el futuro se realizarán estudios experimentales que evalúen las actividades de los alumnos con COLLECE 2.0 usando el modelo de evaluación de la calidad en uso. La utilización de este modelo sería el punto de partida para tutorizar y guiar en tiempo real las actividades de los alumnos.

Agradecimientos

Este trabajo está soportado por el proyecto CODIFICA, ref. PID2021-125122OB-100, financiado por MCIN/AEI/ 10.13039/501100011033 y los Fondos Europeos de Desarrollo Regional (FEDER) “*Una manera de hacer Europa*”.

Referencias

[1] L. Silva, A. J. Mendes and A. Gomes, ’Computer-supported Collaborative Learning in Programming Education: A Systematic Literature Review,’ 2020 IEEE Global Engineering Education Conference (EDUCON), Porto, Portugal, 2020, pp. 1086-1095

[2] P. Dolog, L. L. Thomsen, and B. Thomsen, ‘Assessing Problem-Based Learning in a Software Engineering Curriculum Using Bloom’s Taxonomy and the IEEE Software Engineering Body of Knowledge’, ACM Trans. Comput. Educ., vol. 16, no. 3, May 2016.

[3] C. Piech, M. Sahami, D. Koller, S. Cooper, and P. Blikstein, ‘Modeling How Students Learn to Program’, in Proceedings of the 43rd ACM Technical Symposium on Computer Science Education, Raleigh, North Carolina, USA, 2012, pp. 153–160.

[4] J. Leinonen, L. Leppänen, P. Ihantola, and A. Hellas, ‘Comparison of Time Metrics in Programming’, in Proceedings of the 2017 ACM Conference on International Computing Education Research, Tacoma, Washington, USA, 2017, pp. 200–208.

[5] N. C. C. Brown, M. Kölling, D. McCall, and I. Utting, ‘Blackbox: A Large Scale Repository of Novice Programmers’ Activity’, in Proceedings of the 45th ACM Technical Symposium on Computer Science Education, Atlanta, Georgia, USA, 2014, pp. 223–228.

[6] R. S. Pettit, J. Homer, and R. Gee, ‘Do Enhanced Compiler Error Messages Help Students? Results Inconclusivé, in Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education, Seattle, Washington, USA, 2017, pp. 465–470.

[7] S. Salomón, R. Duque, J. L. Montaña, and L. Tenés, ‘Towards automatic evaluation of the Quality-in-Use in context-aware software systems’, Journal of Ambient Intelligence and Humanized Computing, Feb. 2022.

[8] ISO/IEC 25010:2011. Systems and software engineering. Systems and software Quality Requirements and Evaluation (SQuaRE). System and software quality models, 2011.

[9] M.A, Redondo, S. Sánchez, C. Gómez, C. Lacave, A.I. Molina and M. Ortega, ‘COLLECE 2.0: Un sistema para el aprendizaje colaborativo de la programación sobre Eclipse, con una metáfora multidimensional para la visualización de programas’, en actas de las XXVI Jornadas sobre Enseñanza Universitaria de la Informática, Valencia, España, 2020, pp. 109-116.

[10] J. Li, F. Liying, X. Qing, Z. Shi and X. Yiliu, ‘Interface generation technology based on Concur Task Tree,’ in Proceedings of the International Conference on Information, Networking and Automation (ICINA), Kunming, 2010, pp. V2-350-V2-354.

[11] R. Duque, C. Bravo and M. Ortega, ‘A model-based framework to automate the analysis of users' activity in collaborative systems’, Journal of Network and Computer Applications, 34, 4, 2011, pp. 1200-1209.

[12] S. Schez-Sobrino, C. Gmez-Portes, D. Vallejo, C. Glez-Morcillo and M. Á. Redondo, ‘An Intelligent Tutoring System to Facilitate the Learning of Programming through the Usage of Dynamic Graphic Visualizations’, Applied Sciences, vol. 10, no. 4, 2020.

EXPLORING THE POTENTIAL OF MODERN BOARD GAMES TO SUPPORT COMPUTATIONAL THINKING

Fábio Machuqueiro
Institute of Education
University of Lisbon
Lisbon, Portugal
fmachuqueiro@edu.ulisboa.pt

João Piedade UIDEF,
Institute of Education
University of Lisbon
Lisbon, Portugal
jmpiedade@ie.ulisboa.pt

***Abstract*— The modern board game market (MBG) has been evolving gradually, and its mechanics appear to support concepts of Computational Thinking (CT). Seen as pedagogical resources applicable in the classroom context, this study analysed 10 MBGs with the aim of identifying aspects that can promote the development of CT, with a special focus on the modern board game 'Rossio.' Building upon the LM-TM model, an adapted version of the LM-GM model for board games, we propose a new framework that relates Computational Thinking learning mechanics (CTLM-TM) with tabletop game mechanisms.**

***Keywords*— Computational Thinking, Game Mechanics, Modern Board Games**

I. INTRODUCTION

Modern board games (MBGs), also known as "hobby games"[1], are unplugged activities [2], with sophisticated and contemporary designs that have gained popularity in recent years. More complex than traditional board games, MBGs require high levels of interaction and present a significant strategic complexity with move planning, decision-making, and problem-solving, making them a valuable tool for the development of Computational Thinking (CT). This article investigates the relationships between game mechanics and CT development by analysing 10 selected MBGs based on specific criteria. The analysis was conducted systematically, using the CTLM-TM model [3], a modified version of the LM-TM model , originally adapted from the LM-GM model [4], to identify the connections between game mechanics and CT learnings.

II. BACKGROUND

A. *CT Concepts*

Wing [1] defined CT as a cognitive ability that utilizes strategies from computer science to solve problems, develop systems, and understand human behaviour. While debates about the processes involved in CT continue to exist, its definition has inspired other researchers who have dedicated themselves to studying this construct with a focus on the future. This has led many countries to incorporate CT into their educational curricula, recognizing its importance in developing students' abilities. However, it's important to note that there is still no global consensus on a precise definition of CT. This lack of uniformity has posed challenges in the field of CT education, as different definitions and approaches have emerged over time. Table 1 presents different concepts used in some of the existing definitions of CT:**1)** Wing[1]; **2)** Berland and Lee [5]; **3)** Barr and Stepheson [6]; **4)** Brennan and Resnick [7]; **5)** Selby and Woolard [8]; **6)** Grover and Pea [9]; **7)** Seiter and Foreman [10]; **8)** Kalelioğlu [11]; **9)** Angeli et. al [12]; **10)** Repenning et.al [13]; **11)** Scirea and Valente [14].

TABLE I. CONCEPTS USED IN SOME EXISTING CT DEFINITIONS.

	1	2	3	4	5	6	7	8	9	10	11
1-Abstraction	x		x	x	x	x	x	x	x	x	x
2-Algorithmic Thinking	x	x	x		x	x	x	x	x		x
3-Automation			x			x		x		x	
4-Collaboration						x					
5-Computational Artefacts					x						
6-Conceptualising								x			
7-Conditionals		x		x		x					x
8-Conditional Logic		x		x		x					x
9-Control Structures			x								
10-Data Analysis						x		x		x	x
11-Data Collection			x	x				x			
12-Data Representation			x	x		x		x			x
13-Debugging		x		x		x		x			x
14-Decomposition	x		x		x	x	x	x	x		
15-Distributed Computation		x									
16-Evaluation					x	x					
17-Events				x							x
18-Generalisation					x	x	x		x		
19-Heuristic Thinking											x
20-Incremental Thinking				x		x					x
21-Iterative						x					x
22-Loops				x							x
23-Logical Thinking/Reasoning						x					
24-Mathematical Reasoning								x			
25-Modelling		x	x		x			x			
26-Modularising				x							x
27-Operators											x
28-Pattern Generalisation						x					
29-Pattern Recognition	x					x		x			
30-Parallelisation			x					x			
31-Parallelism				x		x					x
32-Recursive	x					x					
33-Reusing/Remixing				x							x
34-Sequences				x							x
35-Simulation		x	x		x			x			
36-Testing			x	x		x		x			x

B. *The rise of MBG*

"Board games have always been very popular. Classic games like Chess and Checkers, as well as commercial games like Monopoly and Scrabble, have made their mark on various generations. However, Modern Board Games (MBGs) are distinct, as they feature innovative designs, sophisticated mechanics, and high-quality materials. Currently, sales data for MBGs suggest that we are in a 'Golden Age' [3], with thousands of new games being released every year. The emergence of 'geek' culture, the resurgence of interest in social interaction, and the search for new forms of entertainment, especially during the Covid-19 pandemic, have contributed significantly to the growth of this post-digital movement [15].

In fact, digital communication itself has supported the growth of MBGs, with several websites and blogs dedicated to this analogue resource. The Board Game Geek (BGG) website (https://boardgamegeek.com/) is a notable example, serving as the primary source of information about MBGs [3]. Worldwide, events, gatherings, and meetings are organized, such as Essen Spiel and Gen Con [16], for playing MBGs and, in some cases, discussing their pedagogical applicability. In Portugal, Leiria Con and its academic conference, Leiria Talks, stand out, aiming to reflect on the role of board games in today's society. All of this hype also led to the establishment of the Spiel des Jahres (https://www.spiel-des-jahres.de/), which has been awarding the best produced and published games since 1979.

However, it is important to note that there is a wide variety of MBGs, and not all are the same. Sousa and Bernardo [17] have developed a taxonomy of board games, highlighting the characteristics of MBGs. Among these characteristics, their innovative mechanics stand out, providing greater strategic depth and, consequently, a greater intellectual challenge [18]. These factors have sparked the interest of the scientific community [5], [14], [19], leading some researchers to consider that the exploration of MBGs can be considered in the development of CT.

C. *Mechanics for the Development of CT*

In 2011, Berland and Lee [5] turned to the modern board game Pandemic [20] to highlight the creation of spaces for the development of CT through students' discursive interaction. From this initial work, there was a clear awakening of the scientific community to the potential of this activity. In 2016, Berland and Duncan [19] demonstrated that the social component of MBGs can generate interactions that promote CT. More recently, in 2019, Scirea and Valente [14] analysed board games through an approach that, although limited, aims to help teachers and game designers identify games potentially capable of developing CT in the classroom. From these works, we identified 12 mechanics of MBGs that are particularly conducive to the development of CT, subsequently relating them to the recent work of Englestein and Shalev [21]. The authors refer to these mechanics as tabletop game mechanisms, grouping them in a repository for reference. The three-letter code represents the thematic group, divided into: Game Structure (STR), Turn Order and Structure Terminology (TRN), Actions (ACT), Resolution (RES), Game End and Victory (VIC), Uncertainty (UNC), Economics (ECO), Auctions (AUC), Worker Placement (WPL), Movement (MOV), Area Control (ARC), Set Collection (SET), and Card Mechanisms (CAR). On the other hand, the numbers represent the specific mechanism, as evidenced in Table 2.

III. METHODS

The universe of modern board game mechanics is still somewhat unclear. In fact, a brief literature review reveals a lack of consensus between the concepts of mechanics and mechanisms. If we look at digital games, Schell [22] tells us that mechanics are the procedures and rules of the game. However, Adams and Dormans [23] drew attention to the fact that rules and mechanics differ between analogue and digital games, as in analogue games, a full understanding of the rules is mandatory before playing.

TABLE II. RELATIONSHIP BETWEEN SELECTED MECHANICS AND ENGLESTEIN AND SHALEV (2019) MODEL.

	Selected Mechanics	Relationship with Englestein and Shalev (2019) descriptive code	Relationship with the Engelstein and Shalev (2019) Tabletop Games Mechanisms
	Action Queues	ACT	06 - Action Queues
	Area Majority/Influence	ARC	02 - Area Majority/Influence
	Cooperative Game	STR	02 - Cooperative Games
	Dice Rolling	RES	19 - Dice Selection
	Hand Management	CAR	06 - Drafting
	Modular Boards/Tile Placement	MOV/SET	21 - Pieces as Map/ 02 - Tile Lying
	Pattern Recognition	SET	02 - Tile Lying
	Real-Time	TRN	07 - Real-Time
	Simultaneous Action	TRN	09 - Simultaneous Action Selection
	Turn Order	TRN	01 - Turn Order (Various)
	Simulation	ACT	04 - Action/Event
	Worker Placement/Resource Management	WPL	01 - Standard Worker Placement

The authors emphasize the idea that mechanics may be related to rules but depend primarily on the active participation of the player. Indeed, these authors assert that many researchers do not distinguish between the mechanics of analogue and digital games, which can lead to some confusion due to the differences between the game systems and dynamics present in each of them. One of the most evident confusions in analogue game studies is the semantic distinction between game mechanics and game mechanisms. Järvinen [24] claims they are the same, referring to the processes that players use to achieve the game's objectives. In this article, we start from this principle: Game mechanics and game mechanisms correspond to the same concept.

In this context, Plass et al. [25] highlighted that game mechanics support the player's actions, allowing for the compression of the game system and creating spaces for learning. If we consider the use of MBGs with a specific learning objective, it becomes essential to analyse the game according to the objectives we set. For a learning mechanic to help a player learn during the exploration of an MBG, it must be implemented during the gameplay through the game mechanic.

Therefore, this article aims to explore the potential of ten MBGs in the development of CT in students of the 1st Cycle of Primary Education, using a new framework, the CTLM-TM, a modified version of the LM-TM model by Sousa and Dias [3], originally adapted from Arnab et al [4] LM-GM.

D. *Search Strategy*

In this research, Portuguese and international board game publishers present in the Portuguese market and authors of educational projects using MBGs with a focus on commercial games capable of inadvertently developing CT were identified. Based on previous studies [5], [14], [19], various mechanisms were listed, and their combination resulted in gameplay mechanics that seemed to support CT development.

Subsequently, the Boardgamegeek (BGG) database was accessed (October 2022) to identify several MBGs that encompassed the suggested mechanisms. A total of 824 games were found, and through inclusion/exclusion criteria (Table 3), 10 MBGs were selected for this analysis (Table 4).

TABLE III. INCLUSION CRITERIA USED IN THE SELECTION OF MBG

Inclusion Criteria	Rationale
Phase One	
Publisher: a) Portuguese; b) with presence in the Portuguese market; c) uses MBG pedagogically.	Rules in Portuguese or easily adaptable.
Considered an original board game in its base form.	Focus on the "base game," excluding expansions and re-implementations.
Published starting from 2006, inclusive.	Jeannette Wing defined the concept of CT in 2006.
Minimum of 4 players.	Most of the researched MBGs from publishers were designed for 4 players. In the classroom, creating tables with more players per table helps the facilitator's instructional process.
Playable within a maximum of 45 minutes.	Children have lower concentration levels in long-duration tasks and are easily distracted [26].
Recommended for children between 8 and 10 years old.	Researched MBG are predominantly recommended for children aged 8 and above. The 1st Cycle of Primary Education typically lasts until the age of 10.
Phase Two	
Possesses a minimum of two game mechanisms that are favorable to the development of CT.	Multiple distinct mechanisms generate game mechanics that are favourable to the development of CT through discursive interaction.
Phase Three	
Thematically adaptable to the subjects present in the "Novas Aprendizagens Essenciais" curriculum.	Board games motivate players to learn more about a topic [27].

A. *Modern Board Games Selected*

The following table summarizes the selected MBG, highlighting the game mechanics identified in each of them according Englestein and Shalev (2019). For the encoding of the games, the following elements were used: NM - game name/CD-Code, RK BGG - BGG ranking, YR - year, PL - players, PT - playing time, AGE - recommended age, GM - game mechanic according Engelstein and Shalev [21].

B. *Modern Board Games Analysis*

Relating game mechanics to learning mechanics is not an easy task. It is crucial to conduct a literature review, taking into account previous studies. Arnab et al. [4] argued that it should be defined at a higher level, encompassing objectives, rules, and pedagogical value. The lack of knowledge about how mechanics relate to learning led these authors to create the LM-GM framework, aimed at serious games.

TABLE IV. SUMMARY OF SELECTED MBG AND THEIR RESPECTIVE MECHANICS ACOORDING ENGLESTEIN AND SHALEV (2019) TABLETOP GAMES MECHANICS.

NM/CD	RK BGG	YR	PL	PT	AGE	TM
Flamme Rouge (FRO)	235	2016	4	45	8	ACT-06; CAR-06; MOV-21/ SET-02; TRN-09; ACT-04
Kingdomino (KDO)	262	2016	4	25	8	MOV-21/ SET-02; TRN-02
Kanagawa (KAN)	752	2016	4	45	10	CAR-06; SET-02; TRN-02; WPL-01
Forbidden Island (FIS)	858	2010	4	30	10	STR-02; CAR-06; MOV-21/ SET-02
Treasure Hunter (THU)	1671	2015	6	40	8	CAR-06,TRN-09
Prehistorias (PHI)	4163	2020	5	30	8	MOV-21/SET-02; SET-02; TRN-02
Rossio (ROS)	5219	2020	4	45	8	CAR-06,MOV-21/SET-02; SET-02
King of the Dice: The Board Game (KDB)	9584	2021	4	45	8	ARC-02; RES-19; SET-02
Festival (FES)	15637	2022	4	30	8	MOV-21/SET-02; SET-02
I.R.I.S. Desafio en La Fábrica (IRI)	N/D	2022	1[a]	30	10	ACT-06; STR-02; TRN-07

[a] Exception to the rule due to its proximity to STEM technologies.

Building on the idea that serious games provide intrinsic learning due to the interaction between the player and the game system, the authors identified various game mechanics capable of promoting specific types of learning. However, Sousa and Dias [3] argued that the game mechanics of serious games do not align with those of modern board games. To bridge this gap, they created the Learning Mechanics-Board Game Mechanisms (LM-TM) model, establishing a connection between the learning mechanics (LM) and game mechanics (GM) defined by Arnab et al. [4] and the game mechanisms proposed by Engelstein and Shalev [21]. Following this line of thought, they also reformulated the identified learning mechanics in the LM-TM model, directly linking them to CT Learning Mechanics (CTLM) (see Table 5).

Considering these relationships, we must not forget the strategic depth observed during gameplay, the dynamism, materiality, and the continuous need for clarification and rule consultation. The unique characteristics of these analogue games require the ongoing participation of someone acting as a facilitator, clearly explaining the game rules, objectives, and victory conditions [3]. This aspect is transferred to the CTLM-

TM model, similar to the LM-TM model, through the "Tutorial," "Feedback," and "End Game Achievement." In fact, the Tutorial and Feedback correspond to the internalization of rules and the constant development of mental strategies capable of optimizing these rules [5].

Regarding CT, several concepts are observable during the "Play Round" and Berland and Lee [5] stated that the use of conditional logic, logical reasoning, and debugging occurs gradually as the rules are internalized. Optimizing the rules and player behaviour in response to game dynamics, for example, requires a progressively efficient execution of rules and the creation of various algorithms that allow players to achieve desired outcomes. The analogies highlighted become even more relevant when considering that board games are rule-based systems and require players to perform tasks that are often handled by a computer in video or console games.

TABLE V. CROSSING RELATIONS AMONG LM, CTLM AND TM

Learning Mechanics	CT Learning Mechanics	Tabletop Mechanics
a) Instructional b) Tutorial c) Demonstration / Guidance	1/2/3/6/7/9/10/12/13/14/16/18/21/22/23/24/25/26/27/28/29/32/34	Rules Explanation* STR/ACT
d) Participation	1/4/6/10/11/12/14/16/17/18/23/24/28/29/32/34	Rules Explanation* STR
e) Generalization/ Discrimination	1/2/3/7/13/18/22/25/27/29/34	Rules Explanation* Rules Consultation* ACT
f) Observation	10/11/12/16/29	Game Components
g) Feedback	2/8/9/10/13/16/17/18/20/21/22/23/24/29/30/31/34	TRN/VIC/RES
h) Explore/Discover	1/2/3/6/7/10/11/13/14/16/18/20/22/25/26/27/29/34	ACT/MOV
i) Plan	2/6/9/14/20/21/23/26	ECO/ACT/MOV
j) Hypothesis	1/2/3/7/13/22/24/25/27/34	ACT
k) Experimentation	1/2/3/11/12/33/35	Game Components*
l) Analyse	8/10/20/22/24/29	RES/VIC
m) Action/Task	1/2/3/7/13/14/22/25/27/34/36	ACT
n) Modelling/ Simulation	1/2/3/6/7/8/9/10/11/12/13/14/16/17/18/19/20/21/22/23/24/25/26/27/28/29/30/31/32/34/35/36	TRN/RES/VIC ACT/ECO/WPC/ MOV/ARC/SET/ CAR
o) Reflect/Discuss	2/8/9/10/16/17/18/19/20/21/22/23/24/30/31/32/33/34/35	RES/TRN
p) Imitation	1/2/4/6/8/9/10/17/20/21/22/23/24/27/30/31/34	RES/TRN
q) Shadowing	1/2/9/13/21/27/32/34/	UNC
r) Assessment	8/10/13/16/18/20/21/22/23/24/25/26/27/32/34	RES/VIC
s) Competition	2/7/8/10/21/24/30/31	TRN/VIC
t) Motivation	2/8/9/10/17/20/21/22/23/24/30/31/34	TRN/RES/VIC
u) Ownership	1/2/4/6/9/16/17/21/22/23/24/30/31/32/33/34	TRN/VIC
v) Accountability	8/10/16/20/22/24/32/33/28/29	RES/VIC
w) Responsibility	1/2/3/6/7/8/9/10/17/20/21/22//23/24/30/31/32/34	TRN/RES/VIC
x) Repetition	1/2/3/6/7/8/10/11/12/13/14/16/18/19/20/21/22/23/24/25/26/27/28/29/32/33/34/36	ACT/ECO/WPC/ MOV/ARC/SET/ CAR

IV. Results

A. Applying the CTLM-TM Model: The case of Rossio Morden Board Game

To test the CTLM-TM model, we used the board game Rossio [28] during a pilot study. The game was explored by students from a 1st Cycle of Primary Education class at Adelaide Cabette School Group in Odivelas, Lisbon. The gaming experience took place once a week for a month, through classroom gaming sessions. Five game tables were set up, playing five different copies of the same game, generously provided by Phytagoras Games. 20 students played the game, 11 boys and nine girls, aged between 8 and 12 years old. During the gaming sessions, discursive evidence from the students was collected through the use of logbooks for subsequent analysis. The game did not undergo significant rule changes; however, more time was dedicated to explaining it. In the game setup, students began by delineating the game board (Rossio square), reserving the necessary space for laying down tiles (pavement pieces). Next, they shuffled 96 tiles to form a draw pile. Two initial tiles were randomly selected and placed on the game board. Afterward, they shuffled 40 pavement card tiles with different patterns and formed a face-down draw pile. Four cards were randomly drawn from the top and laid out in a row, face-up, forming the pavement card market. A supply of coins and a supply of various point tokens were set up.

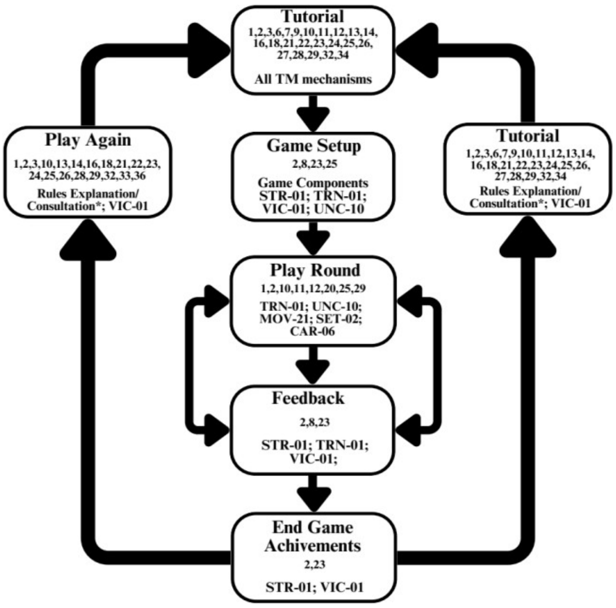
Individually, each player received a small board, known as a workshop. Each player randomly drew four pavement pieces for their workshop and drew five pavement cards, choosing only three to keep. Through several rounds, clockwise, students took their turns in three phases: 1) Recruiting a pavement card, paying the activation cost, or selling a pavement card to gain money to activate pavement cards; 2) Constructing pavement pieces in Rossio square, matching the patterns of the pieces to those on the pavement cards; 3) Drawing new pavement cards from the market and new pavement pieces. Students earned points for the patterns they constructed in Rossio square. When the last pavement piece was placed in the square, the endgame trigger was activated, and points were tallied.

The application of the CTLM-TM model, adapted from the LM-TM version [3], to the game Rossio allowed us to create an analysis example. In addition to the mechanics identified on BGG, during the research phase, we considered others according to the studies by Engelstein and Shalev [21]. Therefore, the following mechanics were retained for this analysis:

• Competitive gameplay mode (STR-01)
• Turn order (TRN-01)
• Management of pavement cards with patterns for future score maximization (CAR-06)
• Addition of pavement pieces to the game board (MOV-21)

• Construction of patterns present on pavement cards (SET-02)
• Drafting cards from the pavement card market (CAR-06)
• Variable setup, dependent on: 1) initial card drafting; 2) tiles present in the workshop; 3) two initial tiles placed on the game board (UNC-10)
• Victory points are earned based on the evaluation of specific conditions (VIC-01)

After identifying the game mechanics present in Rossio, a modified version of the CTLM-TM model adapted to the specific situation of this game was developed. This version is illustrated in figure 1.



CTLM	TM	Game Activity
All CT concepts are included.	Rules Explanation/ Consultation*	Reading and understanding the rules of the game.
Data Representation (12)	Game Components*	Analogue manipulation of cards, pieces, and other components to gather, organize, and analyse information.
Logical Thinking/Reasoning (23)	STR-01 Competitive Games	Activation of logical reasoning processes to predict the consequences of actions taken and anticipate opponents' moves.
Algorithmic Thinking (2)	TRN-01 Fixed Turn Order	Players constantly adjust their strategies to deal with turn-to-turn features such as available money or the cards available in the market.
Conditional Logic (8)	VIC-01 Victory Points from Game State	Using gameplay actions to trigger events that allow for the maximization of the score in compliance with specific conditions (e.g., matching more complex patterns results in more victory points).
Modelling (25)	UNC-10 Variable Setup	Players create multiple mental representations of different game configurations, leading to the development of distinct strategies based on different scenarios
Incremental Thinking (20)	MOV-21 Pieces as a Setup	The game map is expanded through the strategic allocation of tiles, gradually improving the player's score.
Pattern Recognition (29)	SET-02 Tile-Lying	Players formulate mental sequences of movements based on the patterns they collect, devising tactics for the placement of their tiles. Control structures are introduced whenever the player makes decisions about the shape, colour, or position of the tile.
Abstraction (1) Data (10,11,12)	CAR-06 Drafting	The characteristics of each pattern card, as well as the need for them to meet certain conditions for selection of the cobblers require players to have high levels of abstraction.

Fig. 1. CTLM-TM model applied to MBG Rossio

B. *Applying the CTLM-TM Model to other MBG.*

"Flamme Rouge" [29] is a MBG in which players take on the roles of cyclists with distinct abilities. Through the "Action Queue" mechanic, players use cards from their individual decks to program their movements. The mechanics of "Simultaneous Action Selection", “Draft” (Hand Management) allow for parallel and object-oriented movement programming. The game also features "Action/Event" (Simulation) mechanisms that model real-world elements, such as the Tour de France, and “Piece as Map/Tile Lying" (Modular Board) mechanics, which enable the construction of different courses with varying levels of complexity and incremental challenges.

"Kingdomino" [30] is an MBG, winner of the Spiel des Jahres in 2017, that involves the strategic placement of domino tiles to expand kingdoms. The main mechanic is “Tile Lying” (Tile Placement”, which requires abstraction skills and pattern recognition to connect terrains of the same type and maximize points. The game also develops logical reasoning and algorithmic thinking with its “Turn-Order” (Turn-Based) mechanic, as it requires players to constantly adjust their strategies to deal with varying turn-to-turn features, such as current score or available resources. Certainly, the "Draft" mechanism in Kingdomino, where players analyse available dominoes to build the game board, fosters strategic decision-making in line with algorithmic thinking. Players must adapt and adjust their strategies iteratively to the evolving game dynamics.

In "Kanagawa" [31] players take on the roles of disciples in an art school, guided by the ideals of Master Hokusai, as they strive to create harmonious paintings. The "Turn-Order” (Turn-Based) mechanic allows for strategic selection of paintings to create, while "Standard Worker Placement” (Worker Placement/Resource Management) enables the manipulation of painting techniques associated with various colour codes, fulfilling the necessary conditions for scoring points. "Draft” (Hand Management) and the "Tile Lying” (Pattern Building) mechanic require analysis of different cards to identify distinct and increasingly complex patterns. Claiming the first player action expands tactical possibilities and demands algorithmic thinking to create the best strategy.

In "Forbidden Island" [32], players use the "Cooperative Game” (Cooperation) mechanism to work together to rescue treasures from a cursed island before it is submerged by the waters of the ocean. Each player can take up to three actions per turn: 1) move characters; 2) use individual character abilities; 3) pass treasure cards or help drain water from adjacent tiles. Players must collectively reflect to overcome various obstacles, and the discussions arising from these reflections create opportunities for the development of algorithmic thinking due to constant strategic decision-making, gradual debugging of increasingly complex rules, and conditional logic present in player interactions.

"Treasure Hunter" [33] is a MBG where players compete to obtain the highest number of treasures. The mechanics of "Simultaneous Action Selection” and "Draft” (Hand Management) complement each other to create a game with more strategy and tactics than initially expected. At the beginning of the game, several cards are chosen simultaneously, each with a strength value and a colour associated with a treasure zone. Players need to manage their cards and decide which ones to use in each treasure dispute, considering various conditions present throughout the game, such as the number of treasures in each zone. The game can be seen as an analogy to the structuring of complex data in a computer.

In “Prehistorias” [34] we hunt animals represented by polyomino tiles of various shapes and sizes. In the first phase, the "Draft” (Hand Management) mechanic allows us to activate hunters, considering that the fastest one’s hunt first and the strongest ones have access to polyominoes with more animals. This mechanic, besides supporting the analysis of each card's characteristics, also supports the concept of encapsulation related to Object-Oriented Programming. Thus, discarded cards function as hidden internal data of the external interface: the player's hand. The "Turn Order” (Turn- Based) mechanic promotes algorithmic thinking and logical reasoning through timely planning of strategies based on the chosen types of hunters and polyominoes. In the second phase of the turn, the polyominoes are placed on an individual board (cave) that takes the form of a 7x7 grid. The "Tile Lying” (Tile Placement) mechanism encourages incremental thinking through orthogonal placement of pieces. Certainly, the game also includes goals proposed by elders that require filling the cave through "Tile Laying" in its Pattern Building variant.

"King of Dice: The Boardgame" [35] is a game with a "Dice Selection” (Dice Rolling) mechanic, where the results allow players to acquire cards. These cards enable players to expand their territory by placing new tiles, acquiring gemstones, or reclaiming castles attacked by dragons. The dice rolling mechanism appears to support the development of skills similar to those observed in computational data analysis processes, as the information present in the physical dice of the game is analysed and evaluated based on certain conditions. The "Area Majority/Influence” (Area Control) mechanic promotes algorithmic and heuristic thinking, as players assess their actions and decide which areas, they want to control by placing castle tiles. Finally, the "Tile Lying” mechanic, in its Pattern Building variant, is evident in fulfilling certain conditions with colour or number sequences, increasing the likelihood of success.

"Festival" [36] is a MBG game that recreates the movement of the crowd during a music festival. Players control groups of fans, represented by polyominoes, who move throughout the festival based on their preferences: visiting one of the four stages, buying food or drinks, or purchasing merchandise. The game mechanic of "Tile Lying” (Tile Placement) is used to represent the movement of the crowd, with players placing their polyominoes in different locations of the festival. This action is highly incremental, taking into account the player's current position and planning future movements to maximize their score. The mechanic of "Tile Lying”, in its Pattern Building variant, requires players to recognize and construct patterns with different symbols found on objective cards in order to earn more points.

The inclusion of the game "I.R.I.S. Desafío en La Fabrica" [37] is an exception to the selection criteria used, as it was chosen for its approach to STEM methodology. This MBG tells the story of IRIS, a factory robot that awakens after a lightning strike hits the control centre of its factory. Through the "Action Queues" mechanic, we use action tokens to program all of IRIS's movements in 40 levels of increasing complexity. In the scope of this research, the "Cooperative Game” (Cooperation) mechanic has been adapted, hoping that the players' discourse and debate on how to program the Robot IRIS can create spaces for the development of Computational Thinking through the creation of algorithms, logical reasoning, or the satisfaction of certain conditions. By being played in "Real-Time," it also activates a process of quick decision-making, where sequential actions end up creating various events processed by the Robot IRIS.

The following table (table 6) summarizes all the games analysed in this article. The games are listed in the rows, and the mechanics are listed in the columns. We have placed a "check" if the game implements that particular mechanic and the associated digit for the resulting Computational Thinking learning mechanic (see table 1).

TABLE VI. SUMMARY OF ANALYZED MBGS USING THE CTLM-TM FRAMEWORK

	Action Queues	Area Majority/ Influence	Cooperative Games	Dice Selection	Drafting	Pieces as Map/ Tile Lying
FRO	✓ 34				✓ 1, 10	✓ 20
KDO					✓ 1,2, 10,21	✓ 2,23
KAN						
FIS			✓ 2,8, 13,31		✓ 1, 10 11,12	✓ 20
THU					✓ 1,10, 11,12	
PHI					✓ 1,10, 11,12	✓ 20
ROS					✓ 1,10 11,12	✓ 20
KDB		✓ 2,19		✓ 1,10, 14,20		
FES						✓ 20
IRI	✓ 34		✓ 2,8,			

	Action Queues	Area Majority/ Influence	Cooperative Games	Dice Selection	Drafting	Pieces as Map/ Tile Lying
			13,31			

	Tile Lying	Real-Time	Simultaneous Action Selection	Turn Order (Various)	Action/Event	Standard Worker Placement
FLR			✓ 31		✓ 25	
KDO				✓ 2, 23		
KAN	✓ 29			✓ 2,23		✓ 8, 10
FIS						
THU			✓ 31			
PHI	✓ 29			✓ 2,23		
ROS	✓ 29			✓ 2,23		
KDB	✓ 29					
FES	✓ 29					
IRI		✓ 17				

DISCUSSION

It seems evident that the analysed mechanics support the development of CT, although some in an ambiguous way, as highlighted by Scirea and Valente [14], among other studies reviewed by Machuqueiro and Piedade [2] in a recent state-of-the-art review. However, the actual contributions of these analogue games are not yet fully clarified. Understanding the contribution of MBG and its mechanics is relevant for CT, as we believe we are facing a resource that can be highlighted as the preferred disconnected activity for CT development.

As Sousa et al.[38], state, several mechanisms compose the game mechanics that directly connect to the dynamics experienced by players. In our opinion, this dynamism present during the gameplay flow provides highly engaging experiences and interactions for CT development.

Therefore, we analysed ten analogue games using a CTLM-TM model, an adaptation of the LM-TM model by Sousa and Dias [3], originally adapted from the LM-GM model by Arnab et al. [4], relating tabletop game mechanics to possible CT learning mechanics.

When comparing game mechanics to CT learning mechanics, there are several variables to consider. Regarding CT learning mechanics, the variables are even more extensive, as there is still no consensus among researchers on this construct. The CTLM-GM framework takes into account the characteristics of tabletop games, as seen in the work of Sousa and Dias, as well as various CT mechanics introduced based on studies by some researchers. However, it is clear that a tabletop game mechanism can activate multiple CT learning mechanics, especially as players internalize the rules.

The "Action Queue" mechanic appears to be the one that best promotes CT, particularly due to its resemblance to programming. "Simultaneous Actions" remind us of practices of parallelism and events, providing immediate responses to actions taken. The "Modular Boards" mechanic supports the development of incremental thinking, especially in games with an expandable playable area, which activates processes of decomposition. The "Cooperation" mechanic, widely cited in the scientific literature [5], [19] fosters continuous discourse among players, activating parallelism, conditional logic, debugging, and algorithmic thinking. The "Turn- Based" mechanic, in addition to promoting logical reasoning, works on the sequencing of actions, while "Resource Management," "Worker Placement," and "Hand Management" mechanics refer us to the field of data and variables. The "Real-Time" mechanic requires players to demonstrate great dexterity and cognitive flexibility to fulfil specific events and conditions. "Area Control" encourages players to use heuristic and algorithmic thinking to solve problems related to territorial control on the game board. On the other hand, "Dice Rolling" promotes the interpretation of data and variables, encouraging players to consider multiple possibilities when faced with specific conditions to meet. Finally, strategic thinking, driven by the diversity of mechanisms and mechanics present, appears to be present in most of the analysed analogue games, making the games more complex and promoting the development of algorithmic thinking.

CONCLUSION

Given the growing interest of the scientific community in activities that promote CT and the resurgence of new board games, we decided to explore this realm to study the relationships between MBGs mechanics and CT learning. However, the world of MBGs remains largely uncharted territory due to their innovative designs, strategic depth, and limited available studies. Nevertheless, we believe that MBGs mechanics have the potential to provide a conducive environment for CT development. The CTLM-TM framework aims to provide guidance for establishing these relationships when exploring an MBG. The result is a systematic analysis of ten MBGs based on the CTLM-TM, with the goal of providing a method for analysing this type of resource. In addition to supporting an ongoing doctoral project, this framework can be valuable for any educational agent or game designer seeking to recognize the potential of MBGs in CT development.

THREATS VALIDATION AND FUTURE RESEARCH

It is important to note that the set of board game mechanics analysed in this study does not cover all the ones that could potentially support CT development, which is the main limitation of our work. Therefore, we believe that conducting a similar analysis with a larger sample of MBGs and even other analogue games would likely reveal a broader and more promising set of board game mechanics/CT learning mechanics. Furthermore, there is a significant need to further deepen studies of this nature in order to relate learning mechanics and game mechanics based on player behaviour and discourse. As Berland and Lee [5] suggest, this approach could yield highly promising results.

Another limitation, as exemplified by any of the games, is that the presented game mechanics, although conducive to CT development, are constrained by the context of their application. This means that the criteria presented for game selection should be understood as a helpful but limited guideline, as creating environments for CT development requires considering physical space, the surrounding environment, and the methodology of application.

In the future, our work aims to implement a doctoral project in two primary school classrooms, using some of the analysed MBGs within the framework of CTLM-TM. The objective will be to utilize experimental and control groups, conduct descriptive and inferential statistical analysis, as well as qualitative analysis based on discourse records, to understand the real contribution of MBGs to CT development. However, other avenues can also be pursued, such as conducting workshops with teachers to assess the quality of the described assumptions.

Acknowledgment

We would like to express our gratitude to the publishers Haba España and Old Teddy's Company, S.L., Maldito Games, Mercurio Distribuciones, Phytagoras, and GDM Games for providing us with the analogue games.

References

[1] J. Wing, “Computational Thinking,” *Commun. ACM*, vol. 49, no. 3, pp. 140–158, 2006, doi: 10.4018/978-1-7998-4576-8.ch006.
[2] F. Machuqueiro and J. Piedade, “Development Of Computational Thinking Using Board Games: A Systematic Literature Review Based On Empirical Studies,” *Rev. Prism. Soc.*, vol. n.º38, pp. 5–36, 2022, [Online]. Available: https://revistaprismasocial.es/article/view/4766.
[3] M. Sousa and J. Dias, “From learning mechanics to tabletop mechanisms: Modding steam board game to be a serious game,” *21st Int. Conf. Intell. Games Simulation, GAME-ON 2020*, pp. 41–48, 2020.
[4] S. Arnab *et al.*, “Mapping learning and game mechanics for serious games analysis,” *Br. J. Educ. Technol.*, vol. 46, no. 2, pp. 391–411, 2015, doi: 10.1111/bjet.12113.
[5] M. Berland and V. R. Lee, “Collaborative strategic board games as a site for distributed computational thinking,” *Int. J. Game-Based Learn.*, vol. 1, no. 2, pp. 65–81, 2011, doi: 10.4018/ijgbl.2011040105.
[6] V. Barr and C. Stephenson, “Bringing computational thinking to K-12: What is involved and what is the role of the computer science education community?,” *ACM Inroads*, vol. 2, no. 1, pp. 48–54, 2011, doi: 10.1145/1929887.1929905.
[7] K. Brennan and M. Resnick, “New Frameworks for studying and assessing the development of computational thinking,” 2012.
[8] C. Selby and J. Woollard, “The Developing Concept of Computational Thinking,” *Informatics Educ.*, no. October 2018, pp. 1–3, 2013, [Online]. Available: http://eprints.soton.ac.uk/401033/1/161002TableofC%26CT.pdf.
[9] S. Grover and R. Pea, “Computational Thinking in K-12: A Review of the State of the Field,” *Educ. Res.*, vol. 42, no. 1, pp. 38–43, 2013, doi: 10.3102/0013189X12463051.
[10] L. Seiter and B. Foreman, “Modeling the learning progressions of computational thinking of primary grade students,” *ICER 2013 - Proc. 2013 ACM Conf. Int. Comput. Educ. Res.*, pp. 59–66, 2013, doi: 10.1145/2493394.2493403.
[11] F. Kalelioğlu, Y. Gülbahar, and V. Kukul, “A Framework for Computational Thinking Based on a Systematic Research Review,” *Balt. J. Mod. Comput.*, vol. 4, no. 3, pp. 583–596, 2016.
[12] C. Angeli *et al.*, “A K-6 computational thinking curriculum framework: Implications for teacher knowledge,” *Educ. Technol. Soc.*, vol. 19, no. 3, pp. 47–57, 2016.
[13] A. Repenning and A. Basawapatna, “Emerging Research, Practice, and Policy on Computational Thinking,” *Emerg. Res. Pract. Policy Comput. Think.*, no. July 2020, 2017, doi: 10.1007/978-3-319-52691- 1.
[14] M. Scirea and A. Valente, “Boardgames and Computational Thinking: How to identify games with potential to support CT in the classroom,” in *FDG '20: Proceedings of the 15th International Conference on the Foundations of Digital Games*, 2020, pp. 1–8, doi: 10.1145/3402942.3409616.
[15] F. Cramer and F. Cramer, “What Is ‘Post-digital’?,” no. January 2013, pp. 12–26, 2015.
[16] T. Donovan, *It's All a Game: The History of Board Games from Monopoly to Settlers of Catan*. Thomas Dunne Books, 2017.
[17] M. Sousa and E. Bernardo, “Back in the game modern board games,” *Commun. Comput. Inf. Sci.*, vol. 1164 CCIS, pp. 72–85, 2019, doi: 10.1007/978-3-030-37983-4_6.
[18] S. Woods, *Eurogames : The Design, Culture and Play of Modern European Board Games*. McFarland & Company, Inc., Publishers, 2012.
[19] M. Berland and S. Duncan, “Computational Thinking in the Wild: Uncovering Complex Collaborative Thinking through Gameplay.,” *Educ. Technol.*, vol. 56, no. 3, pp. 29–35, 2016.
[20] M. Leacock, “Pandemic.” Pegasus Spiele, 2008, [Online]. Available: https://boardgamegeek.com/boardgame/30549/pandemic.
[21] G. Engelstein and I. Shalev, *Building Blocks of Tabletop Game Design*. 2022.
[22] J. Schell, *The art of game design: A book of lenses, 3rd edition*. 2019.
[23] E. Adams and J. Dormans, *Game Mechanics*. United States of America: New Riders, 2012.
[24] A. Järvinen, *Games without Frontiers: Theories and Methods for Game Studies and Design*, vol. 7, no. January 2007. 2008.
[25] J. L. Plass, B. D. Homer, C. Kinzer, J. Frye, and K. Perlin, “Learning Mechanics and Assessment Mechanics for Games for Learning,” Games Learn. Inst. Manuscripts, no. January, pp. 1–19, 2011, doi: 10.13140/2.1.3127.1201.
[26] D. Nizam and L. C. Law, “In the eyes of young children: A study on focused attention to digital educational games,” in Proceedings of the 32nd International BCS Human Computer Interaction Conference (HCI), 2018, no. July, doi: 10.14236/ewic/HCI2018.20.
[27] R. Y. Bayeck, “Examining Board Gameplay and Learning: A Multidisciplinary Review of Recent Research,” Simul. Gaming, vol. 51, no. 4, pp. 411–431, 2020, doi: 10.1177/1046878119901286.
[28] O. Sá, “Rossio.” PYTHAGORAS, 2020, [Online]. Available: https://boardgamegeek.com/boardgame/276633/rossio.
[29] A. H. Granerud, “Flamme Rouge.” Lautapelit.fi, 2016, [Online]. Available: https://boardgamegeek.com/boardgame/199478/flamme- rouge.
[30] B. Cathala, “Kingdomino.” Blue Orange, 2016, [Online]. Available: https://boardgamegeek.com/boardgame/204583/kingdomino.
[31] B. Cathala and C. Chevallier, “Kanagawa.” IELLO, 2016, [Online]. Available: https://boardgamegeek.com/boardgame/200147/kanagawa.
[32] M. Leacock, “Forbidden Island.” Gamewright, 2010, [Online]. Available: https://boardgamegeek.com/boardgame/65244/forbidden- island.
[33] R. Garfield, “Treasure Hunter.” Queen Games, 2015, [Online]. Available: https://boardgamegeek.com/boardgame/182189/treasure- hunter.
[34] E. Alexandre and T. Benoit, “PreHistorias.” Maldito Games, 2020.
[35] N. Nilsson, “King of the Dice: The Board Game.” Haba España & Old Teddy's Company, S.L, 2021, [Online]. Available: https://boardgamegeek.com/boardgame/352810/king-dice-board- game.
[36] E. Pujadas, “Festival.” GDM Games, 2022, [Online]. Available: https://boardgamegeek.com/boardgame/365840/festival.
[37] J. Krenner, “I.R.I.S. desafío en la fábrica.” Mercurio Distribuciones, 2023, [Online]. Available: https://www.mercurio.com.es/mercurio_shop.html?store-page=I-R-I- S-p470921592.
[38] M. Sousa, N. Zagalo, and A. P. Oliveira, “Mechanics or Mechanisms: defining differences in analog games to support game design,” 3rd IEEE Conf. Games, 2021, [Online]. Available: www.boardgamegeek.com/browse/boardgamemechanic.

YOUNG PEOPLE'S DIGITAL COMPETENCES: DOES GENDER MATTER?

Eduarda Ferreira
Interdisciplinary Centre of Social Sciences (CICS.NOVA) FCSH/NOVA
Lisboa, Portugal e.ferreira@fcsh.unl.pt

Maria João Silva
CIED, Escola Superior de Educação de Lisboa Instituto Politécnico de Lisboa
Lisboa, Portugal mjsilva@eselx.ipl.pt

***Abstract*— This research explores the intersections between gender and young people's self-perceived digital competences. Previous research has identified differences between the self-perceived digital competences of girls and boys, but this paper further explores these differences comparing the ratings of ICT related curricular units with the self-perceived digital competences. A case study in one basic education school of Setúbal, Portugal, analyzed by gender the ratings to the ICT related curricular units, and the results of a digital competences self-assessment online questionnaire. The ICT related curricular units' ratings showed that girls and boys have similar results, however the digital competences self-assessment online questionnaire identifies a lower self-perceived digital competence of girls, and decreasing as they get older. This understanding of how girls' self-perceived digital competences vary with age is an important information to organize educational actions to reinforce girls' self confidence in their digital competences and promote gender equality in technology-related professions.**

***Keywords*— gender, young people, digital competences, ICT**

I. Introduction

Our society is increasingly digital. Everyday life is ever more embedded with digital technologies, with high social and economic impact, shaping the way we live our lives. This digital transformation has a significant impact on the youngest generations and requires young people to quickly build the skills and competences needed for the digital era [1].

The need for digital competences in the work market is rapidly growing [2]. However, the gender gap in Information and Communication Technologies (ICT) studies and careers is an enduring situation [3]. European and Portuguese public policies on digital competence highlight the importance of promoting gender equality in ICT related activities.

Research has identified self-perceived digital competences has one of the major reasons for future career decisions [4], [5]. As such, it is important to further understand gender differences in self-perceived digital competences, particularly in an age of educational and career decisions, such as teenage years. Differences of self-perceived digital competences between boys and girls are well documented [6], [7], but it is important to understand how self-perceived digital competences relate to practices and how they change over the years.

This paper presents one case study research with students of the 7th, 8th and 9th grade, ages ranging from twelve to sixteen years old, of a basic education school in Portugal. The case study analyzed two types of results of boys and girls: ICT related curricular units' ratings, and answers to a digital competences self-assessment online questionnaire. The results are presented and analyzed, and conclusions summarize the main findings. The paper finalizes presenting proposals for further research.

II. Digital Competence and Public Policies

The Council of the European Union adopted a recommendation on key competences for lifelong learning [8] and identified digital competence as one of the key competences essential to citizens for personal fulfilment, a healthy and sustainable lifestyle, employability, active citizenship and social inclusion.

Considering that young people have lived all their lives embedded in digital technologies, it could be expected that they are digitally competent. However, being "digital natives" [9] and having "digital lives" [10], does not imply that young people are automatically digital competent [11]–[13]. Recent research [1] has identified gaps in digital skills, 95% of young people who access the Internet daily, do not inherently possess the skills to use digital technologies safely and effectively. Young people's digital engagement is usually limited to entertainment and communication, and only 13% participate in programming activities. Furthermore, significant inequalities are reported between minority backgrounds and their peers, as well as between boys and girls [1].

Education is central to improve the digital skills of children and young people, and overcoming inequalities [5]. The European Union Digital Education Action Plan (2021- 2027) [14] aims to support the sustainable and effective adaptation of the education and training systems of EU Member States to the digital age. Following the EU Digital Education Action Plan guidelines, Portugal has implemented the Education Digital Transition Plan [15] to promote a digital school, where students, teachers, and schools collaborate, teach and learn in a digital environment. The key initiatives to implement the digital school in Portugal, are: to provide equipment and an internet connection to students, teachers, and schools; to instruct and prepare teachers for a digital world; to provide digital collaboration platforms and access to digital pedagogical resources for students and teachers; and to establish an action plan for digital development in each school. Alongside the Portuguese government established the National Digital Competences Initiative e.2030 (INCoDe.2030) [16], an integrated public policy to enhance and foster digital competences.

The EU Digital Education Action Plan [14], the Education Digital Transition Plan [15] and the INCoDe.2030 [16] identify as one of the main objectives to ensure that girls and young women are equally represented in digital studies and careers. In particular, INCoDe.2030 has an Action Plan "Closing the Gender Gap in Digital Technologies" 2030 Agenda [17] which aims to contribute to challenging stereotypes; the promotion of digital skills and education; and advocate for more women entrepreneurs and in leadership. This action plan understands equality of opportunities not just as equal numbers, but mainly as equal distribution of power. The major challenges are to tackle structural constraints and inequalities, generate inclusive opportunities for girls and women to participate, ensuring that both men and women may be engaged in purposeful and significant education and work activities [17].

Research has identified self-perceived digital competences as one of the reasons why girls do not choose digital studies and careers [4], [6], [18], [19]. And, as such, it is important to further understand gender differences in self-perceived digital competences to be able to promote more equal access to digital studies and careers.

III. ICT AND GENDER

Information and communication technologies (ICT) are part of our lives, being one of the essential aspects of the ways we communicate, work, and socialize. Although ICTs are increasingly a structural aspect of societies, they continue to be a professional area with significant gender differences.

There is an increasing demand for digital skills and higher qualifications in ICT, with employment growth more than eight times higher than the average employment growth in the EU [2]. However, there is a very low number of women ICT specialists in the EU, only around 19,1% of the almost 8 million [2], and a decreasing trend of women graduating in ICT studies over the last decade [3]. In Portugal, there is a significant difference between women and men ICT graduates in higher education, from 2012 to 2021 there has been an average of 80% male graduates and 20% female graduates [20].

The under-representation of women in ICT is not only about gender equality, but it also has implications for the EU's innovative and economic potential in the future. Gender segregation in the labor market reduces the life choices, education and employment options of women and men, further reinforces gender stereotypes and perpetuates unequal gender-power relations in the public and private spheres [21].

Gender disparities in educational decisions and professional choices are not related to innate differences in skills between girls and boys, but rather to different self- representations about competences and aspirations for the future [4]. OECD studies [19] identify social contexts and gender stereotypes as decisive factors in the future career decisions of girls and boys.

In this context, it is important to study the self-perceived digital competences of young people, namely the differences between boys and girls. There are some interesting results of research projects in Portugal that studied digital practices and competences of young people, and that have data on self-perceived digital competences and gender differences.

The Net Children Go Mobile (NCGM) research project, carried out in 2014 in seven European countries, identified gender differences in digital practices [22]. The results in all countries, including Portugal, revealed that boys claim to have more digital skills and show more self-confidence in using computers and the Internet [22].

A recent study in Portugal with children from three to eight years old and their families, 'Growing Up Between Screens' [23], disclosed different strategies of parental mediation for girls and boys: more focused on security issues for girls and in autonomy and exploration of digital practices for boys. By controlling girls' digital practices more than boys, families are restricting girls' opportunities to develop their digital competences, which can have important effects on their career choices [24].

The EU Kids Online network, with the participation of 33 countries, has been investigating the opportunities and risks of the internet for European children and young people since 2010. During the 2017-2018 biennium, a new EU Kids Online survey was carried out in several European countries. In Portugal, the survey was applied in public and private schools and was answered by a national sample composed of 1,974 boys and girls aged 9 to 17 years [25]. The EU Kids Online survey has also explored gender differences in terms of self- representations and found significant differences between boys and girls. Although girls report greater use of mobile platforms, the boys consider themselves more proficient in mobile digital skills. However, girls more than boys report helping their parents when they need help with technology. Girls use more mobile technologies and have the skills to help others, but in self-representation, they report less confidence in their mobile digital skills. The self-representation of their skills is influenced by factors other than their practices [26].

Another particularly interesting and up-to-date research on young people's digital skills is the European project ySKILLS (Youth Skills). This project, funded by the European Union Horizon 2020 program, examines how digital skills mediate the risks and opportunities related to ICT use by 12 to 17 year olds in Europe [27]. In 2021, 2022 and 2023, a group of young people from six countries (Germany, Estonia, Finland, Italy, Poland, and Portugal) answered the same questions about digital access, uses and skills. Four different dimensions of skills are identified: (1) technical and operational skills; (2) information navigation and processing skills; (3) communication and interaction skills; and (4) content creation and production skills [27]. The project results address many items, but we will focus on the Portuguese gender-related outcomes. Gender differences were identified, girls value their communication and interaction skills a little more than boys, and boys are more confident in their technical and operational skills [28].

IV. RESEARCH QUESTIONS

This study aims to explore the intersections between gender and young people's self-perceived digital competences in one basic education school of Setúbal, Portugal. In order to explore these intersections, four sub-questions were used:

- How do girls and boys perform in ICT related curricular units at school?
- Are there differences in the self-perceived digital competences between girls and boys?
- Do the self-perceived digital competences vary with age?

It is important to analyze the ratings of ICT related curricular units to compare with the self-perceived digital competences. This comparison can provide valid information on the accuracy of possible differences of the self-perceived digital competences between girls and boys. Previous research [4], [29], [30] has identified differences between the self- perceived digital competences of girls and boys, but what is the relation with actual performance on ICT related curricular units?

V. Research design

An exploratory case study explored these research questions in context, using diverse collection methods [31]. An exploratory case study allows to describe a case in depth and to identify research questions and methods for further research process. In one basic education school of Setúbal, Portugal, the ratings to the curricular units Information and Communications Technology (ICT) and Programming & Robotics (PR), and the results of a digital competences self- assessment online questionnaire, were analyzed by gender.

A. *Characterization of the participants*

The compulsory education in Portugal is divided into preschool (for those under age six), basic education (nine years, in three cycles) and secondary education (three years). The participants in the research are 366 students (52% boys and 48% girls) from the 3rd cycle basic education of the School Sebastião da Gama. These 366 students are from the 7th grade (146), the 8th grade (116), and the 9th grade (104), with ages ranging from twelve to sixteen years old.

The School Sebastião da Gama is situated in the city of Setúbal, in the Lisbon metropolitan area. Setúbal is a city with a population of 120.000 residents (medium size city for Portugal), at about 40 km from Lisbon, the capital of Portugal.

B. *ICT related curricular units' ratings*

The curricular units' ratings analyzed in this research are Information and Communications Technology (ICT) and Programming & Robotics (PR). The ICT curricular unit is part of the curricular structure of the basic education 3rd cycle. The essential learnings of the ICT curricular unit are organized into four work domains: Safety, responsibility and respect in digital environments; Investigate and research; Collaborate and communicate; Create and innovate. Over the three years, the four work domains advance towards a greater proficiency of the development of students' analytical skills, through the exploration of age-appropriate computing environments and providing an approach to emerging technologies.

The Portuguese curricular structure of the 3rd cycle basic education allows schools to organize local curricular units, and the curricular unit Programming & Robotics is a School Sebastião da Gama offer. The PR curricular unit is specific of the 8th and 9th grade, and its curricular contents, are: Introduction to logical thinking and algorithm; Introduction and exploration of elementary concepts of Computer Science; Exploration of a block-based programming language for developing projects of increasing complexity; Robotics Basics; Distinguish sensors and their functionalities; Initiation of the use of software for robot programming; Programming robots to move in a simple way. These curricular contents are worked over the two years, 8th and 9th grade.

C. *Online questionnaire – digital competences self-assessment*

The online questionnaire was adapted from the online tool of the Digital Skills & Jobs Platform of the European Commission [32], which is based on the European Digital Competences Framework for Citizens DigComp 2.1 [33]. The DigComp 2.1, includes five competence areas: Information and data literacy; Communication and collaboration; Digital content creation; Safety; and Problem solving.

The online questionnaire has two types of questions:

- Self-perceived digital competences - ten questions with descriptors of digital competences and four options to reply: I don't know how to do it; I can do it with help; I can do it on my own; I can do it with confidence and, if needed, I can support/guide others;
- Correct answers - four questions with statements and false/true option + eight questions with a list of software's names or statements, and the participant has to choose the right one(s).

At the end of the online questionnaire there is a description of digital competences: (1) the capacity to use digital technologies, (2) the capacity to use these technologies specifically for work, study and the various activities related to the daily life, (3) the ability to critically evaluate digital technologies and (4) the motivation to participate in digital culture, followed by two questions:

- Which of the following statements about digital competences do you most agree with? (choose only 1 answer): Girls have more digital competences than boys; There are no differences in digital competences between girls and boys; Boys have more digital competences than girls.
- Do a self-assessment of your digital competences, and honestly compare yourself with young people your age. Please indicate which level best suits your self-assessment in a 5-point rating scale, from 1 = much lower to 5 = much higher.

D. *Field work*

The ratings of the curricular units Information and Communications Technology (ICT) and Programming & Robotics (PR) of School Sebastião da Gama during the school year 2021/22 were analyzed. This research collected the ratings of eighteen classes (seven of the 7th grade, six of the 8th grade, and five of the 9th grade) of Information and Communications Technology (ICT), and eleven classes (six of the 8th grade, and five of the 9th grade) of Programming & Robotics (PR).

The online questionnaire of digital competences self-assessment was completed between 19 April and 3 May 2022, in an online environment in the classroom. A total of 366 students answered the questionnaire. To understand how students identify themselves, the questionnaire had the question: Who are you? The answer options were: I don't know, I prefer not to say, a boy, a girl. We have 328 students who identified either as a boy (168) or a girl (160) and whose results we will analyze.

VI. Results

A. *Curricular units' ratings*

The curricular units' ratings of the Portuguese basic education 3rd cycle, range from 1 to 5. The ICT ratings of 366 students and the PR ratings of 220 students have been analyzed. Each grade has a different teacher, but all the classes from the same grade have the same teacher. The means, standard deviation, and t-Test results are identified in Table I and Table II.

TABLE I. ICT RATINGS - INDEPENDENT T-TEST 95% CONFIDENCE INTERVAL

Grade	Girls			Boys			
	N	*Mean*	*StDev*	*N*	*Mean*	*StDev*	*T-test*
7th	78	4.00	0.49	68	3.67	0.47	**t(144) = 4.14, p < .001**
8th	57	3.44	0.65	59	3.16	1.01	t(114) = 1.77, p = .08
9th	57	3.66	0.75	47	3.86	1.07	t(102) = -1.12, p = .28

On the 7th and 8th grade girls ICT ratings mean was higher than boys ratings (Table I), and on the 7th grade the difference is significant t(144) = 4.14, p < .001 (T-test 95% confidence interval). On the 9th grade there is no significant difference between girls and boys rating means, despite boys have a higher rating mean. It is noteworthy that the rating mean difference changes over the years, younger girls performed better than boys, and as they get older boys tended to perform better.

PR curricular unit is mostly about programming and ICT curricular unit is more about production software and digital practices. On PR curricular ratings girls perform better than boys on the 8th grade but the situation changes on the 9th grade, with boys having higher ratings (Table II).

TABLE II. PR RATINGS - INDEPENDENT T-TEST 95% CONFIDENCE INTERVAL

Grade	Girls			Boys			
	N	*Mean*	*StDev*	*N*	*Mean*	*StDev*	*T-test*
8th	57	3.63	0.44	59	3.35	0.30	**t(114) = 4.02, p < .001**
9th	57	3.34	1.09	47	3.90	0.67	**t(102) = -3.07, p = 0.002**

The ICT and PR curricular units' ratings show that girls can perform as well as boys. In the first grades of the 3rd cycle, girls even perform better than boys, and progressively the difference reduces, with a tendency for boys improving their ratings each year. We are aware that these are results from specific classes, in one school in a given school year. They cannot be taken as representative of young people in Portugal. However, these results are important to compare with the results of the digital competences self-assessment online questionnaire.

B. Online questionnaire - digital competences self-assessment

The curricular units' ratings of all the 366 students were analyzed considering that in Portugal all students are identified as a boy or a girl. In the online questionnaire we only analyzed the answers of students who identified themselves either as a boy (168) or a girl (160), in a total of 328 students.

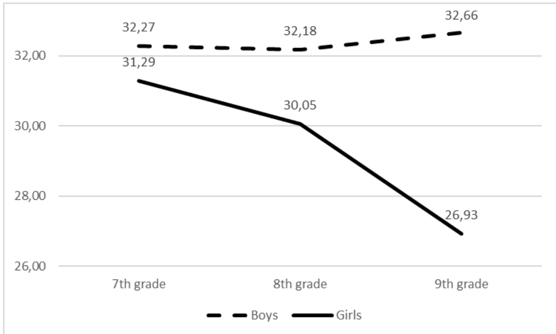
The online questionnaire is a self-assessment instrument and reflects self-perceived digital competences. It does not measure, in any way, real digital competences. The online questionnaire maximum rating is 100, divided equally by the five DigComp areas. The mean results of the online questionnaire, by DigComp area and total, (Table III) show that boys have higher mean results in all DigComp areas, with a greater difference in problem solving, and the exception of information and data literacy. These results are in line with previous research, such as, EU Kids Online [25] and ySKILLS [28].

TABLE III. ONLINE QUESTIONNAIRE MEAN RESULTS - BY DIGCOMP AREA AND TOTAL

DigComp area	Boys n=168	Girls n=160
Information and data literacy	13,05	13,29
Communication and collaboration	14,10	13,65
Digital content creation	11,27	11,06
Safety	12,71	12,09
Problem solving	12,14	10,79
Total	**63,27**	**60,88**

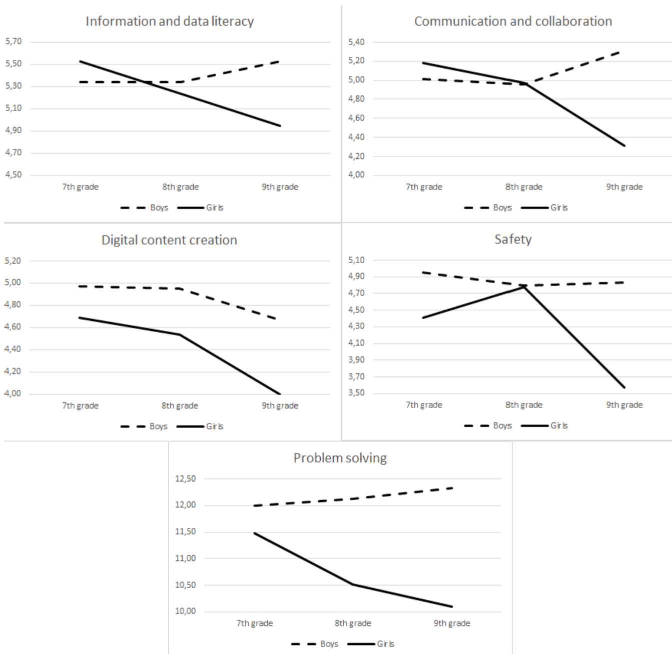
Analyzing the total mean results by sex and grade, we see a trend, girls self-perceived digital competences tend to diminish, and boys tend to increase (Figure 1).

Fig. 1. Mean results of self-perception questions by grade



Looking into more detail and analyzing the mean results by DigComp area and grade (Figure 2) it is possible to identify different trends. Comparing the mean results from the 7th to the 9th grade, we identify a downward trend in all DigComp areas of girls' self-perceived digital competences. Boys, on the contrary, have a trend of growth of mean results in all DigComp areas, except for digital content creation and safety.

Fig. 2. Mean results of self-perception questions by grade and DigComp area



The online questionnaire has self-perception questions and questions with a correct answer. The analysis of the self-perception questions vs. the questions with a correct answer can help understanding the differences of self-perceived the digital competences between boys and girls (Table V).

It is noteworthy that boys' higher mean results are clearly related to the self-perception questions and not to the questions with a correct answer.

TABLE IV. SUM OF MEAN RESULTS FROM SELF-PERCEPTION AND CORRECT ANSWER QUESTIONS

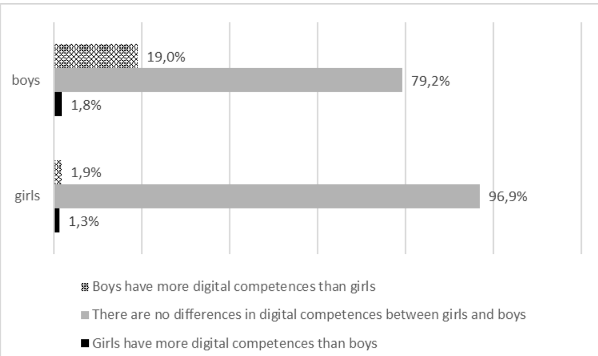
Type of questions	Boys	Girls
Self-perception	32,39	29,73
Correct answers	30,88	31,15
Total	63,27	60,88

If we analyze the results of self-perception questions by grade, it is noteworthy that boys' results tend to increase or to be stable, and the girls' results tend to decrease as they grow older (Figure 1). This tendency is consistent to all DigComp areas (Figure 2), and it must be further studied.

By the 9th grade, in the Portuguese education system, students must decide what area of studies they will proceed. This decision will impact their access to higher education and career opportunities. Previous research has identified self- perceived digital competences as one of the reasons why girls do not choose digital studies and careers [4], [6], [7], [18]. Considering the gender inequality in technology-related professions [17], [21], it is important in future research to expand our knowledge on the evolution of the self-perceived digital competences of girls.

After presenting a description of digital competences (section V. C. Online questionnaire – digital competences self-assessment) students had to choose one of the followed statements: Girls have more digital competences than boys; There are no differences in digital competences between girls and boys; Boys have more digital competences than girls (Figure 3).

Fig. 3. Boys' and girls' choices of the statements about digital competences gender differences

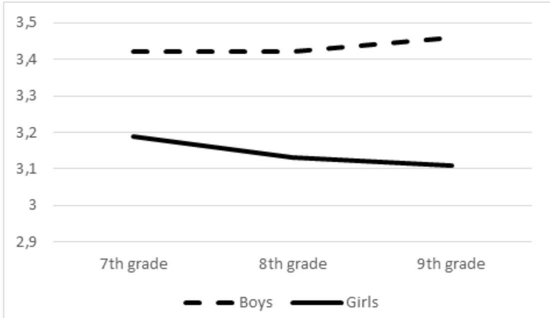


Although most of both girls and boys choose the statement 'There are no differences in digital competences between girls' and boys' (79,2% of boys and 96,9% of girls), there is an important difference between their answers. We have 19,0% of boys choosing the statement 'Boys have more digital competences than girls' and 1,3% of girls choosing the statement 'Girls have more digital competences than boys'. There is a clear difference between girls' and boys' self-representation of their digital competences.

The answers to the final question "Do a self-assessment of your digital competences, and honestly compare yourself with young people your age. Please indicate which level best suits your self-assessment in a 5-point rating scale, from 1 = much lower to 5 = much higher" (Figure 4) further confirm this idea.

Girls mean results to the self-assessment scale of digital competences are lower than boys' mean results and tend to decrease as they grow older. Boys, on the contrary, tend to improve their mean results as they grow older.

Fig. 4. Self-assessment of digital competences on a scale from 1 = much lower to 5 = much higher



Girls mean results to the self-assessment scale of digital competences are lower than boys' mean results and tend to decrease as they grow older. Boys, on the contrary, tend to improve their mean results as they grow older.

Gender differences in self-perceived digital competences in Portugal have been researched before [25], [26], [28], but what is significant in this case study is the understanding that they change during teenage years. School has a major role to change this situation. This knowledge is an opportunity to make a difference and reinforce girls' self confidence in their digital competences.

VII. CONCLUSIONS

This study aimed to explore the intersections between gender and young people's self-perceived digital competences. A case study in one basic education school of Setúbal, Portugal, analyzed by gender the ratings to the curricular units Information and Communications Technology (ICT) and Programming & Robotics (PR), and the results of a digital competences self-assessment online questionnaire.

The ICT and PR curricular units' ratings showed that girls and boys have similar performances. Girls' ratings are as good as boys' ratings, and in the first grades of the 3rd cycle, girls even perform better than boys. Throughout the 3rd cycle boys tend to perform better. However, the ratings of boys and girls are equally positive. If we only analyzed the ICT related curricular units' ratings, we could conclude that girls are as capable as boys of having positive results, with a tendency for boys improving over the years.

However, as we analyzed the results of the digital competences self-assessment online questionnaire, we found some interesting data. The online questionnaire, based on the European Digital Competences Framework for Citizens DigComp 2.1 [33], had two types of questions: self-perceived digital competences and questions with correct answers. On the questions with correct answers, girls' results were as good as boys' results, but on the questions about self-perceived digital competences there was a difference. Girls' self- perceived competences were lower and decreasing by the year in all DigComp areas. So, we can claim that in this case study, we found differences in the self-perceived digital competences between girls and boys, and that they changed over the years. Girls' self-perceived digital competences are lower and decrease as they grow older.

Moreover, in the last part of the online questionnaire, the self-assessment scale of digital competences, further confirmed this idea. Girls' and boys' self-representation of their digital competences is different, girls' have a lower self- assessment of their digital competences. But the most interesting result is the evidence that girls' self-assessment of their digital competences tends to decrease as they grow older, contrary to boys, who increase the self-assessment of their digital competences.

Knowing that self-perception of one's competences is often a cause of academic performance [7], we can advance the hypothesis that it is the decreasing self-perceived digital competences that affect the curricular units' ratings, and not the other way around. Further research is needed to explore this hypothesis.

The interrelation of gender and self-perceived digital competences is well documented [4], [29], [30], but this research contributed with new information about the changes of self-perceived digital competences during teenage years. This new information is particularly important if we consider the impact on girls' and boys' educational and professional choices and that gender inequality in technology-related professions [3], [17] is an enduring reality. The understanding of changes on self-perceived digital competences during teenage years is an opportunity for educational actions. The school can make a difference by reinforcing girls' self confidence in their digital competences and contributing to a more equal society. Further research is needed to expand our knowledge on the interrelations of gender and the evolution of self-perceived digital competences during teenage years.

Acknowledgment

The authors thanks all the teachers and students from the School Sebastião da Gama, who participated in the research. This work is financed by national funds through FCT – Fundação para a Ciência e a Tecnologia, I.P., within the scope of the project «UIDB/04647/2020» of CICS.NOVA – Interdisciplinary Center for Social Sciences NOVA.

References

[1] L. Pašić, A. M. Serban, V. Stefan, D. Potočnik, e D. Moxon, «Social inclusion, digitalisation and young people», Council of Europe and European Commission, 2021.

[2] Eurostat, «'ICT specialists in employment', Statistics Explained», 2021. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=ICT_specialists_in_employment

[3] European Institute for Gender Equality, Women and men in ICT: a chance for better work–life balance : research note. LU: Publications Office, 2018. Acedido: 20 de julho de 2022. [Em linha]. Disponível em: https://data.europa.eu/doi/10.2839/310959

[4] E. Ferreira, «The co-production of gender and ICT: Gender stereotypes in schools», First Monday, out. 2017, doi: 10.5210/fm.v22i10.7062.

[5] OECD, OECD Skills Outlook 2021: Learning for Life. em OECD Skills Outlook. OECD, 2021. doi: 10.1787/0ae365b4-en.

[6] W. Faulkner e M. Lie, «Gender in the Information Society: Strategies of Inclusion», Gend. Technol. Dev., vol. 11, n.o 2, pp. 157–177, jan. 2007, doi: 10.1177/097185240701100202.

[7] OECD, The ABC of Gender Equality in Education: Aptitude, Behaviour, Confidence. Paris: Organisation for Economic Co-operation and Development, 2015. Acedido: 5 de julho de 2022. [Em linha]. Disponível em: https://www.oecd-ilibrary.org/education/the-abc-of-gender-equality-in-education_9789264229945-en

[8] European Commission, Key competences for lifelong learning. LU: Publications Office, 2019. Acedido: 15 de julho de 2022. [Em linha]. Disponível em: https://data.europa.eu/doi/10.2766/569540

[9] M. Prensky, «Digital Natives, Digital Immigrants Part 1», Horiz., vol. 9, n.o 5, pp. 1–6, set. 2001, doi: 10.1108/10748120110424816.

[10] H. Green e C. Hannon, Their space: education for a digital generation. London: Demos, 2007.

[11] E. Ferreira, C. Ponte, M. J. Silva, e C. Azevedo, «Mind the Gap: Digital Practices and School», Int. J. Digit. Lit. Digit. Competence, vol. 6, n.o 3, pp. 16–32, jul. 2015, doi: 10.4018/IJDLDC.2015070102.

[12] E. J. Helsper e R. Eynon, «Digital natives: where is the evidence?», Br. Educ. Res. J., vol. 36, n.o 3, pp. 503–520, jun. 2010, doi: 10.1080/01411920902989227.

[13] N. Selwyn, «The digital native – myth and reality», Aslib Proc., vol. 61, n.o 4, pp. 364–379, jul. 2009, doi: 10.1108/00012530910973776.

[14] European Commission, «Digital Education Action Plan (2021-2027)», 2020. https://education.ec.europa.eu/focus-topics/digital- education/digital-education-action-plan

[15] «Education Digital Transition Plan». https://digital.dge.mec.pt/

[16] «National Digital Competences Initiative e.2030 (INCoDe.2030)». https://www.incode2030.gov.pt/

[17] S. M. da Silva, «Closing the Gender Gap in Digital Technologies», INCoDe.2030, Lisboa, Action Plan, 2018.

[18] OECD, «Gender equality in education, employment and entrepreneurship: Final report to the MCM 2012», OECD, Paris, 2012. [Em linha]. Disponível em: http://www.oecd.org/social/family/50423364.pdf

[19] OECD, The ABC of Gender Equality in Education: Aptitude, Behaviour, Confidence. Paris: Organisation for Economic Co-operation and Development, 2015. Acedido: 5 de julho de 2022. [Em linha]. Disponível em: https://www.oecd-ilibrary.org/education/the- abc-of-gender-equality-in-education_9789264229945-en

[20] «PORDATA Database of Contemporary Portugal». http://www.pordata.pt/

[21] European Institute for Gender Equality, Study and work in the EU: set apart by gender. LU: Publications Office, 2017. Acedido: 20 de julho de 2022. [Em linha]. Disponível em: https://data.europa.eu/doi/10.2839/595585

[22] G. Mascheroni e K. Ólafsson, «Net Children Go Mobile. Risks and Opportunities», Educatt, 2014.

[23] T. S. Castro, C. Ponte, A. Jorge, e S. Batista, «Crescendo entre ecrãs: competências digitais de crianças de três a oito anos», em Literacia, Media e Cidadania – Livro de Atas do 4.o Congresso, Braga: CECS, 2017, pp. 144–157.

[24] E. Ferreira, C. Ponte, e T. S. Castro, «ICT and gender: Parental mediation strategies», em 2017 International Symposium on Computers in Education (SIIE), nov. 2017, pp. 1–6. doi: 10.1109/SIIE.2017.8259671.

[25] B. Ponte, Cristina Susana, «EU Kids Online Portugal. Usos, competências, riscos e mediações da internet reportados por crianças e jovens (9-17 anos)», EU Kids Online e NOVA FCSH, 2019.

[26] E. Ferreira e D. Cardoso, «Género e experiências digitais. Tensões entre estereótipos e autonomias», em NÓS NA REDE: Ambientes digitais de crianças e jovens, Coimbra: Edições Almedina, 2020, pp. 19–36.

[27] Helsper, Ellen J., Schneider, Luc S., van Deursen, Alexander J.A.M., e van Laar, Ester, «The youth Digital Skills Indicator: Report on the conceptualisation and development of the ySKILLS digital skills measure», Zenodo, jan. 2021. doi: 10.5281/ZENODO.4608010.

[28] Ponte, Cristina, Batista, Susana, e Baptista, Rita, «Resultados da 1a série do questionário ySKILLS (2021)», Zenodo, mar. 2022. doi: 10.5281/ZENODO.6376327.

[29] F. Siddiq e R. Scherer, «Is there a gender gap? A meta-analysis of the gender differences in students' ICT literacy», Educ. Res. Rev., vol. 27, pp. 205–217, jun. 2019, doi: 10.1016/j.edurev.2019.03.007.

[30] C. Tømte, «Return to Gender: Gender, ICT and Education», OECD, Centre for Educational Research and Innovation, 2008.

[31] S. L. Pan e B. Tan, «Demystifying case research: A structured–pragmatic–situational (SPS) approach to conducting case studies», Inf. Organ., vol. 21, n.o 3, pp. 161–176, nov. 2011, doi: 10.1016/j.infoandorg.2011.07.001.

[32] «Digital Skills & Jobs Platform of the European Commission».https://digital-skills-jobs.europa.eu/digitalskills/screen/home

[33] European Commission. Joint Research Centre., DigComp 2.1:the digital competence framework for citizens with eight proficiency levels and examples of use. LU: Publications Office, 2017. Acedido: 8 de julho de 2022. [Em linha]. Disponível em: https://data.europa.eu/doi/10.2760/38842

EDUCATIONAL ROBOTICS AND PROGRAMMING IN INCLUSIVE EDUCATIONAL SETTINGS: A SCOPING REVIEW

1st Ana Claudia Loureiro
Center for Research in Basic Education (CIEB)
Instituto Politécnico de Bragança
Bragança, Portugal
0000-0001-7919-6891

2nd Manuel Meirinhos
Center for Research in Basic Education (CIEB)
Instituto Politécnico de Bragança
Bragança, Portugal
0000-0003-1756-709X

***Abstract*—This article presents a map of studies on the educational potential of robotics and programming in inclusive settings. The scoping review methodology was used based on the procedures recommended by the Joanna Briggs Institute. This method was chosen because of the need to examine and map the main trends in the work done with robotics and programming in educational contexts for children with special needs. Our concern was to search for emerging scientific evidence on the educational potential of robotics and programming in inclusive contexts. Searches were conducted in the Scopus, Web of Science, and Eric databases between 2015 and 2022. The analysis identified five research papers that met the inclusion and exclusion criteria. The results show little abundance of studies in this area, which justifies the scoping methodology. The selected studies show a prevalent trend toward the inclusion of educational robotics and not so much programming. They reveal that the use of robotics and/or programming is a pedagogical strategy that promotes greater interaction, participation, and motivation in children, as well as greater socialization. The relevance of the theme and its complexity highlight the need for further research on this subject.**

Keywords— educational robotics, coding, inclusion

I. INTRODUCTION

Since the ratification of the Salamanca agreement in 1994 [1], schools have been concerned with implementing inclusive approaches that promote the success of all students through differentiated strategies and adaptations or curricular and environmental interventions, whenever necessary [2], [3]. The inclusion of children with diverse pathologies in regular education leads us to reflect on appropriate strategies to contribute to their inclusion in the groups or classes where they are inserted and in society in general. For modern education systems and their respective societies, equality and inclusion are unavoidable imperatives. In fact, in some countries, such as Finland, the term "students with inclusion needs" is not used since all students are included, seeking to develop their potential [4]. Portugal, in terms of legislation, also follows this logic [5].

The emergence of the competence school, driven by some countries and international organizations such as the European Union, UNESCO, and the OECD, has led to the creation of digital competence benchmarks for teachers. In these references, it has become increasingly evident that areas, dimensions, or domains that include the description of necessary competencies for teachers within the scope of educational inclusion have been created. More recent benchmarks, such as that of Quebec, even include a specific dimension of digital competencies for inclusion and special needs [6].

In an ever-changing digital society, education faces the challenge of educating for an uncertain world without leaving anyone behind. That is, all students must develop their cognitive potential, aiming for integration in an increasingly technological society, where the use of emerging digital tools becomes more and more relevant. In fact, educational robotics and programming are inseparable when trying to develop computational thinking skills at an early age. At these ages, robotics can have an advantage by making programming more tangible, while block programming becomes more abstract at the initiation stage of computational thinking [7].

In this school context, several studies argue that educational robotics, due to its characteristics, promotes the inclusion of all, including students with special needs [7]– [10]. Robotics is part of the technological tools available for the development of digital and cognitive skills necessary to live today, and children should start developing them from an early age [11], [12].

Numerous investigations have demonstrated the educational potential of educational robotics integrated with the classroom curriculum [13]–[15] and its potential as a tool for promoting successful curricular inclusion of children with specific needs. Robots are tangible objects that promote the participation and interaction of these children during curricular activities with peers who do not have inclusive needs [16].

Activities with robots involve learning to program, modifying toys, and adding robotic parts, sensors, lights of various colors, or small mechanized movements to them so that they can stimulate and interact with children. Robotics is considered a fruitful re-source in promoting inclusive education in the educational field, not only in social development situations but also as a promoter of cognitive or motor evolution of the children who explore it [9], [17], [18]. Moreover, when programming the robot's movement, students will think about the orientation of the instructions to be given, and consequently, they will need to define laterality and spatial orientation in the movement it must go through to reach its destination, generalizing these skills in everyday life situations. Spatial orientation is not an innate ability. Its structuring is a composition and a mental construction that takes place through movements in relation to objects in the environment, and robotics can be a powerful tool in this learning. By establishing sequences of actions, students are also developing abstraction, as the robot's actions are idealized prior to the action [8].

In turn, it should be recognized that programming is fundamental to supporting activities that can be developed with the help of robots. Moreover, block programming has emerged as a resource to promote cognitive skills in early childhood in a playful way. There are several tools that can be explored at this age, such as ScratchJr (https://www.scratchjr.org) and CODE.org (https://code.org/). These tools are available free of charge for teachers and parents. There are several studies and projects that demonstrate the benefits of programming at these ages in relation to the development of laterality, sequencing, abstraction, communication, and digital literacy. Among these works, we can highlight Bers and Resnick [19], Bers [20], [21], Miranda-Pinto and Osório [22], among others.

In view of these findings, we designed this research based on the scoping literature review methodology with the aim of analyzing an emerging but still little explored field of studies on the use of programming and educational robotics with children with inclusion needs at preschool age and in basic education (1st to 4th grade). Based on this methodology, we sought to examine and map how many and what research studies are on this theme, offering an overview of the literature and the evidence produced in these studies. To this end, we looked for research that could present the educational potentialities of robotics and programming in inclusion contexts. Studies addressing the potential of programming and robotics to provide meaningful learning for children and young people that will enable them to develop the necessary skills required by today's society [11], [12], [23], [24] have given rise to numerous investigations within inclusive education sup-ported by digital technologies. However, these studies do not seem to provide a solid body of information when addressing early childhood inclusion.

Recognition of the importance of digital technologies in promoting skills in children with inclusion needs goes back some time. For Sheehy and Green [25], Encarnação et al. [18], Ferm, Claesson, Ottesjö and Ericsson [16], Marcão [10], González-González [17], the important thing is to find ways to help these children experience motor experiences, the development of communication skills, manipulation, exploration, and the use of instruments to act on objects and people, promoting cognitive and perceptual development. Carmo [26] is another author who also highlights the need to use technologies that support the interaction, communication, and learning achievement of children with inclusion needs in conjunction with peers without inclusive needs. With the emergence of the computational thinking movement, programming and educational robotics have gained great momentum as support technologies for skill development in school settings. In the literature, we find many studies that have emerged in this area and that demonstrate their importance in the cognitive development of children. What is lacking, however, are more specific studies that demonstrate the pedagogical value of these emerging technologies in inclusive educational settings.

Based on this evidence, we believe that the school environment can promote ideal scenarios for an effective integration of educational robotics and programming through pedagogical strategies and approaches. School classrooms integrate children and young people with different inclusion needs into their classes, and they can equally enjoy the cognitive potential that these technologies can develop. The mapping of studies in inclusive settings for early childhood thus seems to us of extreme relevance.

II. Materials and Methods

We adopted for this study the scoping literature review methodology. According to Pham et al. [27], the purpose of a scoping review is to provide a map or overview of the literature on a topic without the need to perform an extensive data review. For Armstrong, Hall, Doyle and Waters [28], the scoping review can serve to explore the scope of literature in a particular field without describing the findings in detail and to identify the appropriate parameters of a review. Scoping reviews share with systematic reviews their rigor and the use of transparent methods to identify and analyze the relevant aspects of the literature in relation to a topic of interest [27], [28].

The scoping review adopted was based on the model generated by the Joanna Briggs Institute [29], as we considered it to be the most appropriate for the study in question, the aim of which was to examine the extent, scope, and nature of the use of robotics and programming in inclusive educational settings, without intending to describe research findings in detail but rather to map out areas of study where it is difficult to visualize the range of information that may be available and to identify research gaps in this area.

According to Arksey and O'Malley [30], identifying research gaps in a particular area allows one to draw conclusions about the overall state of the literature in that area. However, identifying gaps in the literature through a scoping review will not necessarily identify a lack of research quality since quality assessment is not part of this type of review.

A. *Research Sources*

The search terms were identified from scientific articles in Portuguese, English, and Spanish using Boolean operators in databases to review the literature. The selected sources were Scopus, Web of Science, and Eric, given their significance in the field of educational research. The search was restricted to the years 2015 to 2022. The descriptors used were (i)

inclusion AND *robotic* AND *education*; (ii) *code* AND *"inclusive education*.

B. *Inclusion criteria*

The inclusion criteria used in the research are specified in Table 1.

TABLE I. Inclusion criteria

Inclusion Criteria's	
Publishing years	Articles included in the period 2015–2022
Document type	Research and open and commercial access papers are included; the topic of the paper encompasses the objectives of the review.
Topic	The topic of the document refers to robotics and/or coding in inclusive educational settings.
Population	Articles in which the research covers a population between 5 and 10 years old.
Resource	The use of robotics and/or coding as educational resources is a cornerstone of the research.

C. *Proceeding*

The review is composed of different phases until reaching the result. Initially, 137 documents were identified that matched the established search criteria. Next, duplicate articles (87) were excluded due to their inclusion in the different databases consulted. We discarded 43 articles that, in an initial review, did not mention the use of robotics and/or coding with children with inclusive needs or because the topic was not related to the education of children between 5 and 10 years old, leaving a total of 44. We set out to read the resulting 44 articles and obtained the exclusion of 39 papers that presented studies on different inclusive contexts, such as socioeconomic exclusion, gender discrimination, teacher training courses for the use of robotics resources, and the use of coding for the development of computational thinking in schools, without addressing with specificity children with specific inclusion needs. After this analysis, only 5 articles remained that met the inclusion criteria and the objectives of this study.

Fig. 1 presents the diagram created according to the PRISMA model, in which one can see the process followed in the search, selection, and refinement of the articles found [31].

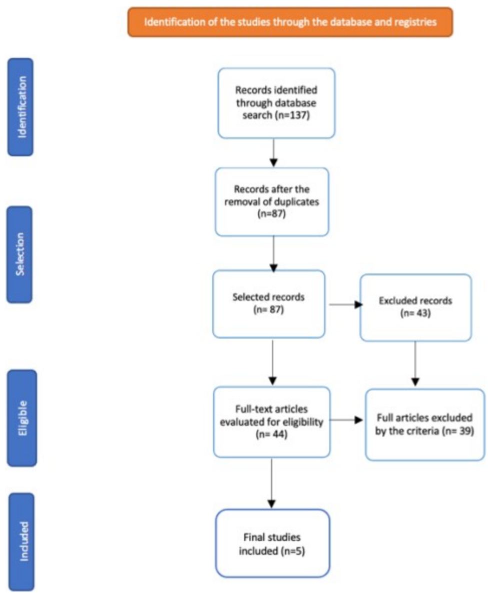


Fig. 1. Research process diagram created according to the PRISMA model[30].

III. Results

According to the results meeting the inclusion criteria, a table was drawn up for data analysis based on the following criteria: (i) year of publication; (ii) context of the studies; (iii) research methodology; (iv) resources used (robotics and/or programming/coding); (v) inclusion educational needs.

A. Years of publication of the selected studies

Table 2 shows the 5 selected sample articles, ordered chronologically. This research was conducted between March and June 2022, and may include articles published after this period that were not included in this study.

TABLE II. Identification of articles by year of publication.

Year of publication	*Reference*	*n*
2015	[2]	(n = 1)
2018	[3]	(n = 1)
2019	[4]	(n = 1)
2021	[1,5]	(n = 2)

B. Contexts of the selected studies

The studies were conducted in four different contexts. Fig. 2 presents the context, specifically the environments in which the selected studies took place.

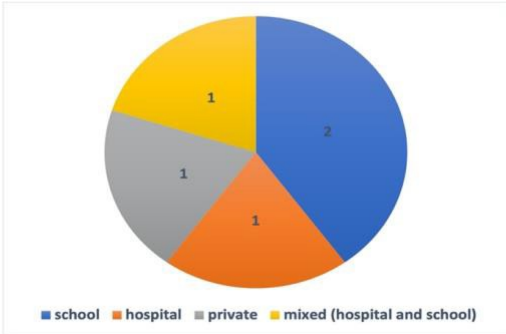


Fig. 2. Study environments.

C. Research Methodology

Regarding the methodological approach adopted in the studies, it was found that a mixed methodology prevails, with analysis of both qualitative and quantitative data (n=5), and action research or experimental research and observation were also adopted in 3 of these studies.

D. Resources

The use of educational robotics is addressed in most of the selected studies (n=4), and only one study presents the use of coding as a strategy for inclusive education. Table 3 shows the resources used in the selected studies.

TABLE III. Identification of the resources used

Study	*Resource*	*Brand*
[1]	coding	programming platforms
[2]	robot	Lego® Mindstorms® NXT® e EV3®, Lego® WeDo®
[3]	robot	Bee-bot®
[4]	coding and robot	Scratch e Makeblock®
[5]	robot	Lego Wedo 2.0®

E. Population and Specific Inclusion Needs

The analysis resulted in studies with different inclusion needs and educational approaches for teaching programming and robotics. Fig. 3 presents these special needs.

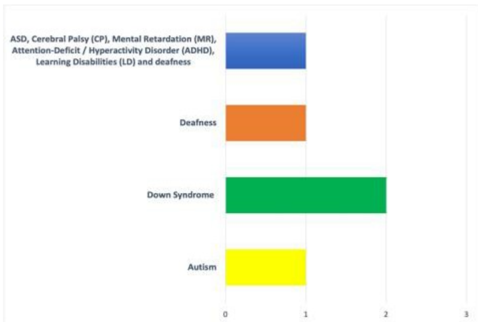


Fig. 3. Different inclusion needs presented in the studies.

IV. Discussion

According to the inclusion criteria, the selected articles had to present studies carried out in educational contexts with a population between 5 and 10 years old and with some specific inclusion needs. Based on criterion (i) publication year, it was found that the year 2021 had the highest number of publications (n = 2), while the previous year's 2015, 2018, and 2019 had only one publication each, which met our objective. Furthermore, it was observed that there were no research publications in 2016 and 2017, according to the criteria and objectives of this study.

Regarding the context, specifically the environments in which the studies were conducted, criterion (ii), it was found that two were carried out in primary schools or educational centers, one was conducted in a health setting, specifically a "hospital laboratory," one was conducted in a private setting, in a parish hall, and another was developed in two environments: educational centers and hospital classrooms.

The methodology, criterion (iii), used in all five studies was mixed methods, with the analysis of qualitative and quantitative data. It was also found that three studies adopted, in addition to mixed methods, action research, experimental research, and observation. These studies were funded by financial foundations.

The most common resource in the analyzed studies, criterion (iv), was educational robotics, with the aim of developing musical skills, computational thinking, motor skills, the Portuguese language, mathematics, cognition, and socialization.

According to criterion (v), the data revealed that studies seeking to meet the specific needs of children with Down syndrome, Autism spectrum disorder (ASD), Cerebral Palsy (CP), Mental Retardation (MR), Attention-Deficit/Hyperactivity Disorder (ADHD), Learning Disabilities (LD), and deafness were prevalent.

In Table 4, we present, in a summarized form, the factors expressed in the research: educational robotics and programming to meet specific needs in inclusive contexts. Note that the table does not seek to establish any relationship between the selected samples but rather illustrates the results in an orderly manner in the analyzed documents.

TABLE IV. CATEGORIZATION OF RESULTS

Population	***Special needs***	***Resource***	***Skills***
8 to 9 years old	Autism	Lego Wedo 2.0®	socialization
5 to 8 years old	Down syndrome	Robot Bee-bot®	cognitive functions and visuospatial memory
4 to 6 years old	Down syndrome	Coding (programming platforms)	computational thinking
5 to 10 years old	Deafness	Scratch e Makeblock®	musical
7 to 10 years old	ASD, CP, MR, ADHD, LD and deafness	Lego® Mindstorms®	Motor skills, Portuguese language, and mathematics

A factor of interest, present in most studies (n = 4), is the proposal of teacher training for the effective use of programming and robotics resources in inclusion contexts. This may be because these samples are studies of action research or experimental research in which the researchers were trainers of teacher training actions. In general, the selected samples present the results of educational actions with children with diverse inclusive needs, presenting activities carried out with robots or programming for the development of skills that promote greater inclusion and socialization of these children in diverse contexts.

The selected studies show a prevalent trend toward the inclusion of educational robotics rather than graphic programming on the screen. The investigations have a mixed nature and address different inclusion needs. The achieved results reveal that the use of robotics and/or programming is a pedagogical strategy that promotes greater interaction, participation, and motivation in children, as well as greater socialization with peers without specific inclusion needs.

V. Conclusions

This paper aims to examine and map the characteristics of studies on the educational potential of robotics and coding in inclusive settings in preschool and basic education. The scoping review methodology is based on the procedures recommended by the Joanna Briggs Institute [29] and aims to examine and map the main concepts and work carried out with robotics and coding in educational contexts with children with specific inclusion needs. The search for data was conducted on the Scopus, Web of Science, and ERIC databases for works published between 2015 and 2022. The review reveals that the topic of inclusion, despite occupying a prominent place in today's digital society, still lacks many studies within the scope of children with specific needs in school settings. This finding is reinforced by the small number of studies found in the accessed databases (n=5) that met the inclusion criteria and objectives of this research.

The theoretical approaches adopted in the studies mainly refer to the educational potential of programming and robotics to provide meaningful learning for children and young people to develop the necessary skills of today's society [11], [12], [24]. All these studies present a theoretical approach to pedagogical strategies that make students active subjects throughout the teaching and learning process, promoting meaningful learning that is constructed by the subject.

The most prevalent technological resource is educational robotics. This may be due to the interaction of children with the robot, which is a tangible and concrete resource compared to programming, which is not tangible and becomes more abstract. However, when we talk about educational activities with robots, coding is intrinsically involved since the robots' movements are the result of programming codes, that is, of coding, whether computer programs or integrated through buttons or commands in the robot itself.

The analyzed studies were conducted in various contexts, with only one study taking place in a private environment within a religious educational institution. Most studies were conducted in school and hospital environments, with an audience between 5 and 10 years old with specific inclusive needs. This suggests a growing interest in inclusive education, which aims to provide equal access to all children attending the early years of basic education (1st to 5th grades). Across all contexts, the studies emphasized the im portance of training education professionals to effectively integrate robotics and coding activities in educational and inclusive contexts.

There was a prevalence of studies that aimed to address the educational needs of children with Down syndrome, autism spectrum disorder (ASD), cerebral palsy (CP), mental retardation (MR), attention deficit/hyperactivity disorder (ADHD), learning disabilities (LD), and deafness. The studies focused on developing various skills, including musical, computational thinking, motor, language, mathematical, cognitive, and socialization skills.

The integration of educational robotics and coding in an inclusive way presents many challenges, particularly in matching the children's ages, curriculum, and developmental areas that are intended to be worked on. The results of this review indicate a scarcity of studies on the use of robotics and programming as educational resources for children with inclusion needs. The relevance of the topic and its complexity highlight the need for further research to fill this gap and enhance early intervention pedagogical practices supported by educational robotics and programming.

Acknowledgment

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the Project Scope: UIDB/05777/2020.

References

[1] UNESCO, «Declaração de Salamanca sobre Princípios, Política e Práticas na Area das Necessidades Educativas Especiais». 1994. Acedido: 14 de maio de 2023. [Em linha]. Disponível em: https://unesdoc.unesco.org/ark:/48223/pf0000139394

[2] J. V. V. d'Abreu e B. L. Bastos, «Robótica pedagógica: Uma reflexao sobre a apropriaçao de professores da escola elza maria pellegrini de aguiar», em *Anais do Workshop de Informática na Escola*, 2013, pp. 280– 289.

[3] C. Conchinha, P. Osorio, e J. C. de Freitas, «Playful learning: Educational robotics applied to students with learning disabilities», em *2015 International Symposium on Computers in Education (SIIE)*, Setubal: IEEE, nov. 2015, pp. 167–171. doi: 10.1109/SIIE.2015.7451669.

[4] A. Schleicher, *Quelle école pour demain?: Bâtir un système scolaire pour le XXIe siècle*. Québec: PU QUEBEC, 2019.

[5] DRE, *Decreto-Lei*. 2018. Acedido: 14 de maio de 2023. [Em linha]. Disponível em: https://dre.pt/dre/detalhe/decreto-lei/54-2018-115652961

[6] Gouvernement du Québec, «Continuum de développement de la compétence numérique». Ministère de l'Éducation et de l'Enseignement supérieur, 2019. [Em linha]. Disponível em: http://www.education.gouv.qc.ca/fileadmin/site_web/documents/ministere/continuum-cadre-reference-num.pdf

[7] C. V. Guerra, F. Moreira, M. J. Loureiro, e I. Cabrita, «Programação tangível para a inclusão e promoção das STEM – contributos para a formação contínua de professores.», *APEduC Rev. - Investig. E Práticas Em Educ. Em Ciênc. Matemática E Tecnol.*, vol. 1, n.º 1, Art. n.º 1, abr. 2020, Acedido: 14 de maio de 2023. [Em linha]. Disponível em: https://apeducrevista.utad.pt/index.php/apeduc/article/view/13

[8] R. M. Casaca e C. Sofia, «Crescer a Brincar - A Robótica no desenvolvimento motor», masterThesis, 2019. Acedido: 14 de maio de 2023. [Em linha]. Disponível em: https://comum.rcaap.pt/handle/10400.26/39496

[9] E. M. dos S. Lourenço, «A utilização das TIC como meio de aprendizagem da matemática com alunos com Necessidades Especiais», masterThesis, 2019. Acedido: 14 de maio de 2023. [Em linha]. Disponível em: https://repositorio.ipv.pt/handle/10400.19/6060

[10] C. I. C. Marcão, «Robots & Necessidades Educativas Especiais: O desenho de uma oficina de formação para a aplicação da robótica educativa em contexto inclusivo», set. 2017, Acedido: 19 de julho de 2022. [Em linha]. Disponível em: https://run.unl.pt/handle/10362/24221

[11] M. Resnick, *Lifelong kindergarten: cultivating creativity through projects, passion, peers, and play*. Cambridge, Massachusetts: MIT Press, 2017.

[12] M. U. Bers, *Coding as a Playground: Programming and Computational Thinking in the Early Childhood Classroom*, 1st edition. New York, NY: Routledge, 2017.

[13] A. Sullivan, M. Elkin, e M. U. Bers, «KIBO robot demo: engaging young children in programming and engineering», em *Proceedings of the 14th International Conference on Interaction Design and Children*, Boston Massachusetts: ACM, jun. 2015, pp. 418–421. doi: 10.1145/2771839.2771868.

[14] W. Johal, G. Castellano, F. Tanaka, e S. Okita, «Robots for Learning», *Int. J. Soc. Robot.*, vol. 10, n.º 3, pp. 293–294, jun. 2018, doi: 10.1007/s12369-018-0481-8.

[15] M. Pinto, M. Fernandes, e A. J. Osório, «CURRICULUM INTEGRATION PROPOSAL FOR KIBO ROBOT IN PRESCHOOL: KIDS MEDIA LAB PROJECT», apresentado na 15th International Technology, Education and Development Conference, Online Conference, mar. 2021, pp. 7910–7921. doi: 10.21125/inted.2021.1591.

[16] U. M. Ferm, B. K. Claesson, C. Ottesjö, e S. Ericsson, «Participation and Enjoyment in Play with a Robot between Children with Cerebral Palsy who use AAC and their Peers», *Augment. Altern. Commun.*, vol. 31, n.º 2, pp. 108–123, abr. 2015, doi: 10.3109/07434618.2015.1029141.

[17] C. S. González González, «Estrategias para la enseñanza del pensamiento computacional y uso efectivo de tecnologías en educación infantil: una propuesta inclusiva: Strategies for teaching computational thinking and effective use of technologies in childhood education: an inclusive proposal», *Rev. Interuniv. Investig. En Tecnol. Educ.*, dez. 2019, doi: 10.6018/riite.405171.

[18] P. Encarnação, L. Alvarez, A. Rios, C. Maya, K. Adams, e A. Cook, «Using virtual robot-mediated play activities to assess cognitive skills», *Disabil. Rehabil. Assist. Technol.*, vol. 9, n.º 3, pp. 231–241, mai. 2014, doi: 10.3109/17483107.2013.782577.

[19] M. U. Bers e M. Resnick, *The official ScratchJr book: help your kids learn to code!* San Francisco: No Starch Press, 2016.

[20] M. U. Bers, *Blocks to robots: learning with technology in the early childhood classroom*. New York: Teachers College Press, 2008.

[21] M. U. Bers, «Coding and Computational Thinking in Early Childhood: The Impact of ScratchJr in Europe», *Eur. J. STEM Educ.*, vol. 3, n.º 3, set. 2018, doi: 10.20897/ejsteme/3868.

[22] M. S. Miranda-Pinto e A. J. Osório, «As TIC em contexto de educação de infância: atividades sobre pensamento computacional e programação.», em *ATAS XIII Congresso SPCE Fronteiras, diálogos e transições na educação.*, Viseu, Portugal: Escola Superior de Educação de Viseu, 2016, pp. 1623–1629. [Em linha]. Disponível em: https://www.spce.org.pt/assets/files/XIII_SPCE_2016_atas_D.pdf

[23] S. A. Papert, *Mindstorms: Children, Computers, and Powerful Ideas*. New York: Basic Books, 1993.

[24] S. A. Papert, *Logo: Computadores e educação.* São Paulo: Brasiliense, 1985.

[25] K. Sheehy e A. A. Green, «Beaming children where they cannot go: Telepresence robots and inclusive education: An exploratory study», *Ubiquitous Learn.*, vol. 3, n.º 1, pp. 135–146, 2011, doi: 10.18848/1835- 9795/cgp/v03i01/40261.

[26] B. Carmo, «Robótica educativa no desenvolvimento do raciocínio matemático», masterThesis, 2013. Acedido: 14 de maio de 2023. [Em linha]. Disponível em: https://sapientia.ualg.pt/handle/10400.1/3625

[27] M. T. Pham, A. Rajić, J. D. Greig, J. M. Sargeant, A. Papadopoulos, e S. A. McEwen, «A scoping review of scoping reviews: advancing the approach and enhancing the consistency», *Res. Synth. Methods*, vol. 5, n.º 4, pp. 371–385, dez. 2014, doi: 10.1002/jrsm.1123.

[28] R. Armstrong, B. J. Hall, J. Doyle, e E. Waters, «"Scoping the scope" of a cochrane review», *J. Public Health*, vol. 33, n.º 1, pp. 147–150, mar. 2011, doi: 10.1093/pubmed/fdr015.

[29] E. Aromataris e Z. (Editors) Munn, *JBI Manual for Evidence Synthesis*. JBI, 2020. doi: 10.46658/JBIMES-20-01.

[30] H. Arksey e L. O'Malley, «Scoping studies: towards a methodological framework», *Int. J. Soc. Res. Methodol.*, vol. 8, n.º 1, pp. 19– 32, fev. 2005, doi: 10.1080/1364557032000119616.

[31] PRISMA-S Group *et al.*, «PRISMA-S: an extension to the PRISMA Statement for Reporting Literature Searches in Systematic Reviews», *Syst. Rev.*, vol. 10, n.º 1, p. 39, dez. 2021, doi: 10.1186/s13643- 020-01542-z.

Potencialidades do uso da Gamificação em um Curso Online Aberto e Massivo

Potentials of using Gamification in an Open and Massive Online Course

Mariella Berger Andrade
Centro de Referência em Formação e em Educação a Distância (Cefor)
Instituto Federal do Espírito Santo (Ifes)
Vitória, Brasil
mariella.andrade@ifes.edu.br

Marize Lyra Silva Passos
Centro de Referência em Formação e em Educação a Distância (Cefor)
Instituto Federal do Espírito Santo (Ifes)
Vitória, Brasil
marize@ifes.edu.br

Resumo — No cenário educacional contemporâneo, a gamificação emergiu como uma estratégia pedagógica promissora, embora ainda pouco explorada em *Cursos Online Abertos e Massivos* (MOOC). Este estudo investigou o impacto dos elementos de jogos na prática docente de cursos MOOC, com foco na evasão e na participação e interação dos alunos. Um curso sobre Cultura Maker foi oferecido na plataforma de Cursos Abertos do Instituto Federal do Espírito Santo (Ifes) como cenário para esta pesquisa aplicada, quali-quantitativa e exploratória. Os resultados revelaram que 1969 participantes se inscreveram, com uma taxa de conclusão de 48%. Notavelmente, atividades gamificadas atraíram grande participação, culminando em uma avaliação positiva de 97,13% por parte dos cursistas. Este estudo não apenas destaca a eficácia do uso de gamificação em cursos MOOC, mas também a destaca como uma metodologia inovadora e um catalisador para o engajamento e retenção dos alunos no contexto da educação a distância.

Palavras-chave— Gamificação. MOOC. Inovação. Prática docente.

Abstract – In the contemporary educational scenario, gamification has emerged as a promising pedagogical strategy, although it still needs to be explored in Massive Open Online Courses (MOOC). This study investigated the impact of game elements on the teaching practice of MOOC courses, focusing on student evasion and engagement. A course on Maker Culture was offered on the Open Courses platform of the Federal Institute of Espírito Santo (Ifes) as a setting for this applied, qualitative-quantitative, and exploratory research. The results revealed that 1969 participants signed up, with a completion rate of 48%. Notably, gamified activities attracted significant participation, culminating in a positive evaluation of 97.13% from course participants. This study not only highlights the effectiveness of using gamification in MOOC courses but also highlights it as an innovative methodology and a catalyst for student engagement and retention in distance education.

Keywords— Gamification. MOOC. Innovation. Teaching practice.

I. Introdução

A dificuldade em envolver alunos, em qualquer etapa e modalidade de ensino, no processo de ensino-aprendizagem leva a busca pelo engajamento destes de diversas maneiras, entre elas pode-se citar o uso de gamificação e jogos educacionais que têm se se tornado cada vez mais frequente devido, entre outras características, à sua ludicidade.

O uso de jogos educacionais e gamificação tornou-se cada vez mais frequente, pois *"[..] nos ensinam, nos envolvem e nos motivam de uma maneira pelo qual a sociedade não consegue fazer*" [1]. Para Mattar, isso não ocorre apenas entre jovens e crianças, mas o uso de jogos tem se tornado frequente em todas as idades. Ele afirma que [2] "*É uma ilusão imaginar que apenas jovens jogam games hoje: pessoas de diversas faixas etárias — incluindo, por exemplo, diretores de empresas — também jogam. Por isso, os métodos tradicionais de ensino não conseguem mais envolver os alunos em nenhum nível, nem mesmo na educação online*".

Os Cursos Online Abertos e Massivos, ou na língua inglesa *Massive Open Online Course* (MOOC), diferenciam- se da Educação a Distância (EaD) tradicional pelo fato de serem abertos e livres de pré-requisitos para o ingresso e, sobretudo, em função da quantidade de alunos que normalmente se inscrevem em um curso neste formato [3]. Por serem abertos, os cursos MOOC têm atingido um público que demanda conhecimentos específicos, que muitas vezes não seriam alcançados em formações mais longas e com periodicidade específica.

Nesta perspectiva, esta pesquisa teve como objetivo analisar como os elementos de jogos podem contribuir com as práticas dos professores que atuam na modalidade a distância em cursos MOOC, indicando possibilidades de seu uso e verificando os resultados alcançados com base no índice de evasão e na participação e interação dos alunos em um curso sobre os fundamentos da Cultura Maker, que incorporou elementos de jogos, ofertado na plataforma de Cursos Abertos do Ifes ().

II. Curso Online Aberto e Massivo

Os Cursos Online Aberto e Massivo (ou *Massive Open Online Course* - MOOC) têm como principais características o acesso aberto, um alto poder de disseminação de conhecimento, a gratuidade, o volume de pessoas inscritas, escalabilidade (possibilidade de aumentar o número de alunos gradativamente), acompanhamento da performance do aluno, por meio de atividades que visam determinar o nível de aprendizado, participação assíncrona (no período de oferecimento do curso) e um público muito diverso.

Os cursos MOOC podem ter diversas utilizações, como apresentado por Battestin e Santos [4] que afirma que este tipo de curso pode ser ofertado "*... visando atualização contínua ao longo da vida, aprendizado de novas ferramentas e tecnologias, capacitação de equipes, preparatórios para exames e concursos, nivelamentos de disciplinas, para tratar de conteúdos específicos, para ensinar uma nova língua, para adquirir uma nova competência, entre outros*".

Mas, aqui vale destacar outras características dos cursos MOOC que são a baixa interação entre os alunos e o baixíssimo índice de conclusão, cuja tendência internacional situa-se entre 5% e 15% [5].

Portanto, dadas as suas vantagens e características, os cursos MOOC são importantes ferramentas na oferta de cursos de formação inicial e continuada na modalidade a distância. E, esta pesquisa torna-se importante pois abre novas perspectivas para os cursos MOOC a partir do uso de gamificação em seu planejamento.

III. Jogos e Gamificação

Lev Vygotsky defendia que o desenvolvimento do pensamento da criança tinha bases biológicas, entretanto, que era influenciado, também, pela relação com o meio através das interações estabelecidas entre o sujeito e o ambiente social. Nesse processo, um conceito chave é a mediação, a ação de intermediar a aquisição do conhecimento. A mediação é fundamental para planejar ações, conceber consequências, tomar decisões, imaginar objetos, entre outros.

O professor deve ser o responsável por mediar a aprendizagem utilizando estratégias que levem o aluno a tornar-se independente e estimular o conhecimento potencial, de modo a criar uma Zona de Desenvolvimento Proximal (ZDP) a todo momento. Uma possível estratégia a ser considerada em nossas práticas pedagógicas visando promover tais experiências é o uso da gamificação no espaço escolar.

Mattar nos leva a refletir que "*como educadores, precisamos procurar compreender como os designers de games conseguem atrair as pessoas para aprender games complexos, longos e difíceis. Os designers de games utilizam métodos eficientes para fazer as pessoas aprenderem e gostarem de aprender, sendo, por isso, teóricos práticos do aprendizado. Precisamos então prestar atenção a bons jogos de computador e videogames, e aplicarmos os princípios de aprendizado que eles envolvem*" [2].

De um modo geral, os jogos não apenas desafiam seus jogadores, como também "[...] *prendem a atenção e geram aprendizado*" [2]. Ao jogar, o jogador entra em um estado de fluxo que Mihaly Csíkszentmihályi define como "*... o estado em que as pessoas estão tão envolvidas em uma atividade que nada mais parece importar; a experiência em si é tão agradável que as pessoas a farão mesmo com um grande custo, pelo simples fato de fazê-la.*" [6]. Devido a este grande poder de engajamento proveniente dos jogos, a gamificação que é definida por Rice [7] como a aplicação de elementos presentes em jogos em ambientes no qual estas características não estão presentes naturalmente, passou a ser usada em diversos aspectos, incluindo o âmbito educacional.

Na educação, a gamificação é vista como uma nova forma de aprender e ensinar usando o *game design* [2]. Flora Alves [8], afirma que "*… em termos de aprendizagem, quando pensamos em gamification estamos em busca da produção de experiências que sejam engajadoras e que mantenham os jogadores focados em sua essência para aprender algo que impacte positivamente em sua performance*".

Assim, com a abundância de informações, de conhecimento, de inquietações e de tecnologias disponíveis, torna-se necessária a busca por "*mudanças na organização, nos métodos de ensino e nas abordagens do conteúdo*" [9] a fim de tornar mais atrativo e motivador o processo de ensino-aprendizagem e as minhas práticas pedagógicas. Para tal, a partir de tudo o que foi descrito até o momento, acredito que a gamificação promete ser uma forte aliada para promover tal mudança.

Cada vez mais educadores demonstram interesse em descobrir de que formas os jogos podem ser usados como recursos para apoiar o processo de ensino-aprendizagem [10]. Por serem ambientes capazes de representar e dar novo significado, de maneiras diversas, as informações [11], os jogos educativos são capazes de estimular os alunos através de atividades de competição e cooperação.

Nesse contexto, a gamificação se torna uma importante estratégia para motivar o aluno a executar atividades com propósitos educacionais. Além disso, o termo gamificação consiste na aplicação de mecânicas, estéticas e lógicas presentes em jogos para engajar pessoas, motivar ações, promover o aprendizado e resolver problemas.

Para Mattar [2], o conceito de gamificação tem sido usado muitas vezes de forma pobre e equivocada ao considerá-lo apenas para o uso de premiações, ranqueamento, ou até mesmo confundindo-o com o uso de jogos na educação. Ele afirma que "*podemos gamificar uma aula sem necessariamente usar um game, utilizando por exemplo elementos de games como diversão, interação, conflito, colaboração, competição, recompensas, feedback rápido e constante aos alunos, personalização da aprendizagem e histórias*" [2].

A gamificação, portanto, é uma proposta que visa influenciar a participação grupal em atividades na qual não haveria tanta participação se fossem baseadas em estratégias pedagógicas mais tradicionais. O uso desta estratégia, especialmente, em cursos do tipo MOOC pode aumentar a interação dos participantes e fazê-los concluir o curso.

IV. Percurso Metodológico

A seguir será apresentado o percurso metodológico seguido por esta pesquisa.

A. Locus e Sujeitos da Pesquisa

A pesquisa foi realizada com base no curso "Educador Maker: primeiros passos" ofertado na plataforma de Cursos Abertos do Instituto Federal do Espírito Santo (Ifes). O curso permitia a auto inscrição e ficou disponível na plataforma de cursos MOOC do Ifes durante o ano de 2021 (https://mooc.cefor.ifes.edu.br/moodle/badges/view.php?type=2&id=102).

Os sujeitos da pesquisa foram profissionais da área de educação que têm interesse em conhecer os princípios básicos da Cultura Maker e que se inscreveram no curso voluntariamente. Para se inscreverem, os candidatos precisavam apenas ter computador ou smartphone com acesso a internet.

Responderam a pesquisa 939 alunos que concluíram o curso, que em sua maioria encontra-se na faixa etária entre 19 e 55 anos. Aqui vale ressaltar que estes alunos moravam em todos os estados do Brasil.

B. *Metodologia da Pesquisa*

A pesquisa proposta foi de natureza aplicada, classificada quanto à abordagem como quali-quantitativa e quanto aos seus objetivos como exploratória, pois teve como objetivo "*... proporcionar maior familiaridade com o problema, com vistas a torná-lo mais explícito ou a construir hipóteses*" [12], pois existe pouco conhecimento sobre o tema. Foi também uma pesquisa participante pois segundo Malheiros [13] este tipo de pesquisa "*... além de buscar a compreensão dos eventos que compõem o problema em estudo se concretiza como a própria solução para este*".

C. *Coleta e Análise de Dados*

Para a coleta de dados, foram adotadas duas técnicas: a observação participante e a aplicação de questionário. Para Silva [14], "*... a observação participante, para ser um procedimento válido e fidedigno de investigação, exige do pesquisador um planejamento e uma decisão quanto ao seu grau de observação e participação no contexto em que ocorre o fenômeno pesquisado. Isso equivale a determinar com antecedência "o quê" e "o como" observar*".

O segundo instrumento utilizado na coleta de dados foi um questionário respondido pelos alunos ao final do curso. Moreira e Caleffe [15] afirmam que o uso de questionários tem sido uma das formas mais populares de se coletar dados e citam que sua utilização permite um uso mais eficiente do tempo, colabora para o anonimato do respondente, possibilita uma alta taxa de retorno e a permite a padronização das perguntas.

A análise dos dados foi quali-quantitativa realizada com base na observação participante realizada dentro da sala virtual do curso MOOC, pelas pesquisadoras que, também, foram as idealizadoras do curso. Baseou-se, também, nas respostas coletadas no questionário respondido pelos alunos ao final do curso.

V. Curso Educador Maker: Primeiros Passos

O curso de Formação Inicial e Continuada sobre Cultura Maker proposto, intitulado Educador Maker: Primeiros Passos (Figura 1), teve como objetivo geral permitir que os cursistas reflitam sobre o papel da Cultura Maker na Educação. Este curso teve uma carga horária de 30 horas e não possuía pré-requisitos. Ele foi composto pelos seguintes tópicos: Boas-vindas e Mão na Massa; Cultura Maker; Espaços que inspiram; Mentalidade Maker e Cultura Maker na Educação.

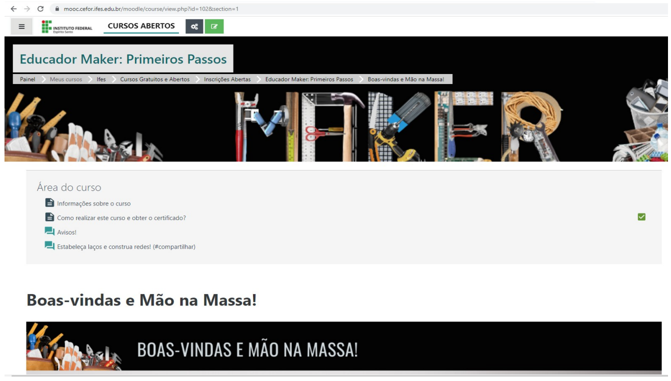


Fig. 1. Curso "Educador Maker: Primeiros Passos"

O curso foi baseado em momentos de estudos individuais e atividades autoinstrucionais, tais como estudos dirigidos, jogos e questionários *online*, como ilustrado no exemplo de uma das seções do curso apresentada na Figura 2.

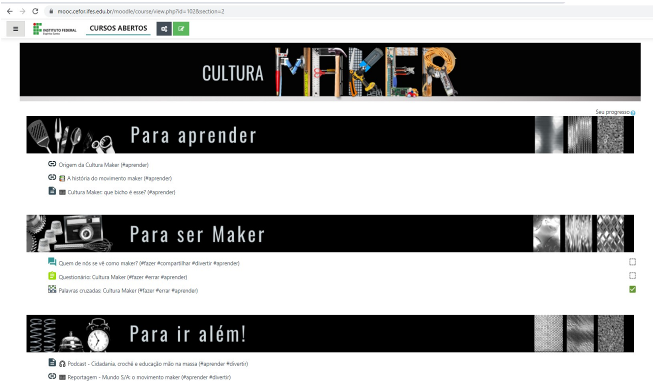


Fig. 2. Exemplo de seção do curso com diversidade de atividades e recursos

Os conteúdos puderam ser estudados de forma livre pelo cursista e foram disponibilizados por meio de vídeo aulas e material complementar (links, vídeos e textos considerados relevantes).

Na metodologia do curso, além da utilização de jogos como estratégia de avaliação, foram propostos 6 desafios para realização de atividades práticas que devem ser postadas com as respectivas reflexões sobre a sua execução em um fórum no qual podem realizar o compartilhamento de experiências ligadas à Cultura Maker. Na figura 3 é possível visualizar um destes desafios, o Desafio da construção de uma Torre de Espaguete.

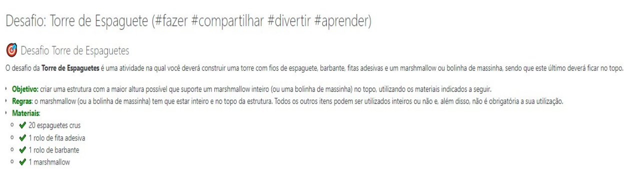


Fig. 3. Exemplo de Desafio proposto no curso

Aos alunos que cumpriram os desafios, não obrigatórios, receberam os seguintes emblemas, conforme apresentado na Figura 4: Mão na massa, Sustentável, Construtor, Aspirante, Colaborativo e Criativo. Um emblema adicional foi entregue ao aluno que concluiu o curso, o emblema Maker Aprendiz. Os emblemas foram construídos no formato de uma caixa de ferramentas e foram incluídas ferramentas na caixa, de acordo com o emblema.

Estes desafios tiveram o objetivo promover a diversão, a interação e a colaboração entre os cursistas. Além de promover estes objetivos, estes desafios liberavam emblemas para os alunos que os conclui-se. Os elementos citados anteriormente são alguns dos elementos de games citados por Mattar [2] que serviram de base para o planejamento dos desafios.

Fig. 4. Emblemas disponíveis no curso

Além dos emblemas, os alunos puderam alcançar níveis de experiência associados à capacidade de interação nos diversos fóruns disponibilizados ao longo do curso a partir do recurso de gamificação nativo do Moodle, o Level Up, conforme apresentado na Figura 5.

Ao planejar a utilização do Level Up associado a quantidade de interações realizada pelos cursistas procurou-se utilizar os elementos de games interação, recompensa e competição citados por Mattar [2].

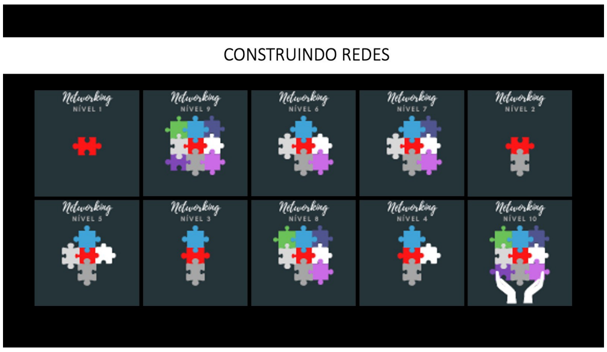


Fig. 5. Níveis de experiência no curso

Para troca de informações e colaboração no caso de dúvidas, os cursistas tiveram à disposição um fórum colaborativo. Neste espaço de compartilhamento os cursistas puderam aprender uns com os outros, de forma colaborativa na construção de seu conhecimento. Por ser um curso MOOC, este curso não teve tutoria.

A avaliação da aprendizagem foi constituída de quatro atividades avaliativas no formato de questionário, método mais comum de avaliação em cursos MOOC, e quatro atividades avaliativas no formato de jogos. Para obter aprovação, o cursista deveria alcançar ao menos 60% da nota máxima no curso, constituída da somatória de todas as atividades avaliativas realizadas.

Ao utilizar as ferramentas de jogos, disponíveis no Moodle, para avaliar os alunos buscou-se promover a diversão e o desafio, dois elementos de jogos citados por Mattar [2].

VI. Resultados

A oferta do curso MOOC Educador Maker: Primeiros Passos foi disponibilizada na plataforma de Cursos Abertos do Ifes no dia 01 de janeiro de 2021 e foi encerrada em 31 de dezembro de 2021. Esse período de disponibilidade do curso foi estabelecido em conformidade com regras da plataforma institucional de cursos MOOC do Ifes.

Participaram 1969 alunos na oferta e 939 solicitaram a certificação. Portanto, o índice de conclusão apresentado no curso foi de aproximadamente 48%, muito superior à tendência internacional, que se situa entre 5% e 15% [5].

Na Tabela I, a seguir, pode-se ver os tipos de recursos e acessos de cada atividade do curso.

TABLE I. ACESSO AS RECURSOS DISPONIBILIZADOS

Atividade	Visuali-zações	Usuários	Recursos ou Atividade Moodle
Informações Gerais			
Informações sobre o curso	1751	1112	Página
Como realizar este curso e obter o certificado?	2341	1511	Página
Avisos!	2454	976	Fórum
Estabeleça laços e construa redes! (#compartilhar)	5146	1113	Fórum
Boas-vindas e Mão na Massa!			
Boas-vindas ao curso	1772	1146	Página
Primeiros passos (#aprender #fazer)	1795	1011	Página
Escolha a sua situação junto ao Ifes	3337	1382	Escolha
Informe sua situação junto à Rede Federal	2048	1358	URL
Apresente-se aos seus colegas! (#fazer #compartilhar)	6120	1158	Fórum (Emblema Maker Aspirante)
Glossário - Cultura Maker (#fazer #compartilhar)	2789	838	Glossário
Cultura Maker			
Origem da Cultura Maker (#aprender)	2337	1138	URL
A história do movimento maker (#aprender)	2051	1005	URL
Cultura Maker: que bicho é esse? (#aprender)	1763	976	Página
Quem de nós se vê como maker? (#fazer #compartilhar #divertir #aprender)	8452	1105	Fórum (Emblema Maker Mão na Massa)
Questionário: Cultura Maker (#fazer #errar #aprender)	15785	1279	Questionário
Palavras cruzadas: Cultura Maker (#fazer #errar #aprender)	9860	1202	Jogo – palavra-cruzada
Podcast - Cidadania, crochê e educação mão na massa (#aprender #divertir)	843	595	Página
Reportagem - Mundo S/A: o movimento maker (#aprender #divertir)	692	530	URL
Espaços que Inspiram			
Espaço Maker (#aprender)	7690	804	Livro
Dicas para inspirar a criação de espaços maker (#aprender)	993	623	URL
Desafio: Torre de Espaguete (#fazer #compartilhar #divertir #aprender)	4820	839	Fórum (Emblema Maker Construtor)
Questionário: Espaços Maker (#fazer #errar #aprender)	10784	1086	Questionário

Atividade	Visualizações	Usuários	Recursos ou Atividade Moodle
Jogo da Força: Espaços Maker (#fazer #errar #aprender)	17410	1057	Jogo – Forca
Podcast - Como montar um laboratório maker na escola (#aprender #divertir)	517	402	Página
Reportagem - Escolas públicas apostam na tecnologia dentro das salas de aula (#aprender #divertir)	454	365	URL
Simulador para montar um laboratório maker (#fazer #divertir)	486	382	URL
Uma Sala Maker na Escola Viva (#aprender #divertir)	423	343	URL
Mentalidade Maker			
Mentalidade Maker (#aprender)	6719	661	Livro
Desenvolvendo a Mentalidade Maker (#aprender)	709	516	URL
O que devo saber sobre esta nova tendência (#aprender)	735	523	URL
Desafio: Carro movido a vento (#fazer #compartilhar #divertir #aprender)	3213	695	Fórum (Emblema Maker Sustentável)
Questionário: Mentalidade Maker (#fazer #errar #aprender)	11351	1024	Questionário
Jogo da Forca: Mentalidade Maker (#fazer #errar #aprender)	15864	1008	Jogo – Forca
Teste: "Você é um verdadeiro maker?" (#fazer #compartilhar #divertir)	2437	698	Fórum – Quiz externo
Podcast - O poder de um professor com a mão na massa (#aprender #divertir)	395	321	Página
Cultura Maker na Educação			
Cultura Maker na educação (#aprender)	4905	613	Livro
Piso baixo, teto alto e paredes amplas: você conhece estes termos? (#aprender)	600	466	Página
Cultura Maker na escola (#aprender)	557	420	URL
Desafio: Cartazes Divertidos (#fazer #compartilhar #divertir #aprender)	3310	605	Fórum (Emblema Maker Criativo)
Questionário: Cultura Maker na educação (#fazer #errar #aprender)	10689	1029	Questionário
Jogo Sopa de Letras (#fazer #errar #aprender)	9222	985	Jogo - Sopa de Letras
Podcast - Como a educação mão na massa chega até a sala de aula? (#aprender #divertir)	311	242	Página
Reportagem - Empreendedores da "Cultura Maker" ajudam estudantes a criar projetos (#aprender #divertir)	279	223	URL
Aprendizagem mão na massa (#aprender #divertir)	280	218	URL
Espaço Maker - Como trabalhar as 10 Competências da BNCC (#aprender)	292	230	URL
Compartilhe Práticas Maker na Educação			
Atividade Maker - Para Escola e Casa (#fazer #compartilhar)	2363	682	Base de Dados (Emblema Maker Colaborativo)

Conforme o Tabela I, acesso aos recursos disponibilizados, percebe-se que a quantidade de participações/visualizações dos jogos e dos desafios, que têm

como recompensa os Emblemas, é muito superior a das outras atividades e recursos disponibilizados no curso. Estas atividades foram planejadas com base em diversos elementos de jogos citados por Mattar [2] conforme destacado anteriormente.

A seguir pode-se ver na Tabela II a quantidade de emblemas liberados para os alunos do curso em atividades não obrigatórias disponibilizadas no curso.

TABLE II. EMBLEMAS RECEBIDOS PELOS CURSISTAS

Emblema	Critérios	Destinatários
 Maker 2021 - Aprendiz	Concluir: "Pesquisa - Avaliação do curso"	955
 Maker 2021 - Aspirante	Concluir: "Fórum - Apresente-se aos seus colegas! (#fazer #compartilhar)"	883
 Maker 2021 - Colaborativo	Concluir: "Base de dados - Atividade Maker - Para Escola e Casa (#fazer #compartilhar)"	253
 Maker 2021 - Construtor	Concluir: "Fórum - Desafio: Torre de Espaguete (#fazer #compartilhar #divertir #aprender)"	457
 Maker 2021 - Criativo	Concluir: "Fórum - Desafio: Cartazes Divertidos (#fazer #compartilhar #divertir #aprender)"	354
 Maker 2021 - Mão na Massa	Concluir: "Fórum - Quem de nós se vê como maker? (#fazer #compartilhar #divertir #aprender)"	625
 Maker 2021 - Sustentável	Concluir: "Fórum - Desafio: Carro movido a vento (#fazer #compartilhar #divertir #aprender)"	389

Além disso, através do plugin Level Up, percebeu-se também um aumento nas interações dos alunos. Verificou-se na plataforma que o nível 10 (nível máximo de interação) foi alcançado por 177 alunos, o nível 9 por 165 alunos, o nível 8

por 58 alunos, o nível 7 por 29 alunos, o nível 6 por 76 alunos e o nível 5 por 81 alunos, totalizando 586 alunos participando ativamente de todos os fóruns.

No final do curso os cursistas, também, responderam a um questionário sobre a qualidade do curso, e teve-se como resultado que 912 (97,13%) dos respondentes avaliaram muito positivamente o curso, 671 (71,46%) alunos classificaram o curso como "Muito bom" e 241 (25,67%) alunos como "Bom").

Por fim, destaca-se algumas respostas abertas dos alunos sobre algum comentário referente ao curso na Tabela III.

TABLE III. DEPOIMENTOS DE CURSISTAS

Cursista	Fala
Cursista 1	"Aprendi bastante com o curso, usou uma metodologia bem didática e fácil compreensão!"

Cursista	Fala
Cursista 2	“Quero ressaltar, para quem ainda não fez esse curso, faça é bem proveitoso, é de suma importância para o crescimento profissional. Parabéns a equipe do MOOC. Mão na Massa”
Cursista 3	“Excelente curso! Parabéns a toda equipe envolvida. Conteúdo de qualidade e com visual muito atraente. Obrigado”
Cursista 4	“Gratidão aos organizadores, pois o curso me fez refletir e repensar minha forma de atuar como professora”
Cursista 5	“Ótimo curso, compilado de informações ricas e didática prazerosa, gostei do lance dos emblemas, genial!”
Cursista 6	“Excelente curso! A forma de avaliação é muito interessante, pois vai exatamente na proposta do maker”
Cursista 7	“Muito interessante. Mostra também novas alternativas de usar o ambiente Moodle.”
Cursista 8	“Parabéns pela plataforma e pela metodologia, muito bem estruturados e pensados.”
Cursista 9	“Curso muito informativo, organizado e "novo" pra mim, gostei da proposta e dos métodos da aprendizagem”
Cursista 10	“Este curso me trouxe muitas aprendizagens, fazendo com que eu fizesse coisas que jamais seria capaz de fazer Aprendi muito, e quero muito mais...”

VII. CONCLUSÃO

O presente estudo investigou o uso da gamificação como estratégia pedagógica inovadora em um Curso Online Aberto e Massivo (MOOC) sobre Cultura Maker oferecido na plataforma do Instituto Federal do Espírito Santo (Ifes). Os resultados obtidos revelam uma taxa de conclusão notavelmente alta de aproximadamente 48%, contrastando significativamente com a tendência internacional de 5% a 15% em MOOC.

O uso estratégico de emblemas, desafios e interações de fóruns transformou a aprendizagem em uma experiência envolvente e colaborativa. A gamificação não apenas motivou os alunos a participarem ativamente. Isso ilustra o poder dos elementos de jogos em criar um ambiente de aprendizagem dinâmico e interativo.

Os resultados indicam não apenas a eficácia do uso da gamificação em cursos MOOC, mas também destacam a importância de repensar as abordagens tradicionais de ensino. Ao incorporar elementos de jogos, os educadores podem transformar o processo de ensino-aprendizagem em uma jornada envolvente, onde os alunos são incentivados não apenas a absorver conhecimento, mas participar ativamente da construção de seu conhecimento.

Além disso, a alta taxa de satisfação dos alunos, conforme demonstrado nas avaliações positivas, valida a abordagem gamificada adotada no curso. Os alunos não apenas aprenderam sobre a Cultura Maker, mas também se sentiram inspirados e motivados a participar ativamente do processo de aprendizagem.

E, por fim, esta pesquisa destaca que a gamificação não é apenas uma tendência passageira, mas sim uma metodologia educacional eficaz que pode revolucionar a forma como os cursos online são projetados. Ao adotar estratégias de gamificação, as instituições de ensino podem criar experiências educacionais mais interativas, envolventes e, o mais importante, significativas para os alunos, preparando-os para enfrentar os desafios do mundo real de maneira criativa e confiante.

REFERENCIAS

[1] J. Mcgonigal. “A Realidade em Jogo”. Tradução: Eduardo Rieche. Rio de Janeiro: Best Seller, 2012.

[2] J. Mattar. “Games em educação: como os nativos digitais aprendem”. São Paulo: Pearson Prentice Hall, 2010.

[3] G. Creed-Dikeogu, and C. Clark. “Are You MOOC-ing Yet? A Review for Academic Libraries”. Kansas Library Association College and University Libraries Section Proceedings, Vol. 3, No. 1, Art. 5, 2013.

[4] V. Battestin, and P. Santos. “ADDIEM – Um Processo para Criação de Cursos MOOC”. EaD Em Foco, 12(1). 2022.

[5] T. R. Liyanagunawardena, P. Parslow, and S. Williams. Dropout: MOOC participants’ perspective. In: “EMOOC 2014, the Second MOOC European Stakeholders Summit” (pp. 95-100), 2014. Lausann, Switzerland: École Polytechnique Fédérale de Lausann. Disponível em: http://centaur.reading.ac.uk/36002/2/MOOC%20Dropout%20Particip
a. Acesso em: 12 abr. 2020.

[6] M. Csíkszentmihályi. “Flow: the psychology of optimal experience”. New York, NY, USA: Harper & Row, 1990.

[7] J. W. Rice. The gamification of learning and instruction: Game based methods and strategies for training and education. “International Journal of Gaming and Computer-Mediated Simulations”, v. 4, n. 4, 2012.

[8] F. Alves. “Gamification - como criar experiências de aprendizagem engajadoras. Um guia completo: do conceito à prática”. 2ª ed. São Paulo: DVS, 2015.

[9] W. Veem, and B. Vrakking. “Homo zappiens: educando na era digital”. Porto Alegre: Artmed. 2009.

[10] J. Kirriemuir,and A. Mcfarlane. “Literature review in games and learning”. Hal Open Science. 2004.

[11] A. Calisto, D. Barbosa, and C. Silva. Uma análise comparativa entre jogos educativos visando a criação de um jogo para educação ambiental. In: “Brazilian Symposium on Computers in Education” (Simpósio Brasileiro de Informática na Educação-SBIE). 2010.

[12] A. C. Gil. “Como elaborar projetos e pesquisa”. 3a ed. São Paulo: Atlas; 1995.

[13] B. T. Malheiros. “Metodologia de pesquisa em educação”. Rio de Janeiro: LTC, 2011.

[14] M. O. S. Silva. “Refletindo a pesquisa participante”. 2 ed. São Paulo. Cortez, 1991.

[15] H. Moreira, L. G. Caleffe. “Metodologia da Pesquisa para o professor pesquisador”. 2ed. Rio de Janeiro: Lamparina, 2008.

THE PORTFOLIO AS A TOOL FOR LEARNING AND ASSESSMENT IN THE INTERNSHIP IN TEACHING INFORMATICS

Ana Claudia Loureiro
Núcleo Interdisciplinar da Criança e do Adolescente (NICA)
Universidade dos Açores
Açores, Portugal
0000-0001-7919-6891

Ana Isabel Santos
Faculdade de Ciências Sociais e Humanas, Núcleo Interdisciplinar da Criança e do Adolescente (NICA)
Universidade dos Açores
Açores, Portugal
0000-0002-9506-7309

***Abstract*— This work arises from the activities developed in the course unit Internship in Informatics Education I, which took place in the 1st semester of the 2022-2023 academic year, focusing, in particular, on the process leading to the elaboration of the portfolio as an active learning strategy, promoting critical, interventional and argumentative reflection on the observation, design and teaching process developed during the professionalizing internship of the Masters Course in Teaching of Informatics at the University of the Azores (UAc). This curricular unit runs in parallel with a curricular unit on Didactics of Informatics I, which aims to contribute to the construction of an informed and pedagogically situated teaching practice, namely at the level of Pre-School Education and the 1st Cycle of Basic Education, framing it within the specificities of the pedagogical environments for which it is intended and where the various pedagogical learning and assessment strategies are focused. Our aim was therefore, on the one hand, to give an account of how the portfolio was introduced in the context of the internship and, on the other hand, to understand how students and teachers were appropriating the use of this tool for the assessment of the curricular unit itself. The study was carried out during the first semester of the first edition of the course and involved the seven students enrolled, all of whom had a 1st cycle degree in Informatics, six of whom had teaching experience in an educational context. In a methodological narrative that followed a reflective and experimental approach, the text raises some aspects worthy of reflection, considering their relevance in the reconstruction of the students' educational action and their own learning process and, consequently, in the children's learning. In general, from the teachers' point of view, the e-portfolios proved to be an effective, practical, and appropriate tool for the students' training context, allowing for continuous and close monitoring of the work that was being carried out and a progressive construction of the reflexivity of the students, future teachers.**

***Keywords*— portfolio, active learning, professionalizing internship, teacher training**

I. INTRODUCTION

Operating since 2022, the master's Course in Teaching of Informatics of the University of the Azores (UAc) comes to offer future teachers of Informatics an innovative and different training that exists within the Portuguese Higher Education in this area. This study plan, designed to train teachers from the recruitment group 550 (Informatics), allows students to have throughout the course specific training in teaching and initiation to professional practice with children and young people of different ages and different levels of education, in a clear commitment to digital training from the early years of schooling. In this sense, throughout the two years of the course, students could carry out their professional internships in Pre-school Education and in the 1st Cycle of Basic Education during the 1st semester, in the 2nd Cycle of Basic Education during the 2nd semester, in the 3rd Cycle of Basic Education during the 3rd semester and in Secondary Education during the 4th semester.

Each of these internships runs parallel to the operation of a curricular unit of Didactics of Informatics that, by providing didactic foundations on the design of educational processes for each of the contexts where students will be immersed, allows them to be scaled aspects of pedagogical and scientific planning, monitoring and evaluation of the activities in each of them, seeking, above all, to promote the training of teachers with legal qualification for teaching in the area of computing, but, at the same time, to broaden horizons regarding the scope that the educational action of these education professionals may have in the regional and national education systems.

The University of the Azores, characterized by being in an archipelagic, insular, and outermost region, and being small, is faced, occasionally, with the need to seek outside teachers who, having more scientific, training and teaching experience, can be an asset to the training processes that we seek to leverage in students. This is the case of the Masters Course in Teaching of Informatics, particularly in the curricular units of Didactics and Internship that, not having a teacher with training and experience in the teaching of Informatics, sought to create synergies with more experienced and skilled teachers in this area, even living outside the region, which could be a clear contribution to the quality of the training that is intended to offer.

Because insularity brings personal and economic costs that are difficult to overcome, the need to ensure regular and continuous participation of a specialist in didactics who could actively participate in these curricular units is being addressed through the use of technology. With teachers of the areas of Education and Informatics of UAc present and permanently in these curricular units, the participation of the specialist has been materialized sometimes in person, at specific moments during the semester, and sometimes at a distance, in a logic of hybrid model of teaching, always guided by the promotion of an active approach to learning that gives priority to the student as the protagonist of his knowledge, by a focus on collaborative learning and learning through action [1]–[3].

Not being a b-learning course, this participation of the specialist in Didactics of Informatics, through distance learning, allows a permanent and continuous monitoring of the activities that the students develop, contributing positively to their training, judging by the evaluation carried out in the first semester of the course, which shows an evolution in the way the students perceive the competences they have developed and how they look at the organization and dynamics of Didactics of Informatics I [4].

This first class of the course had seven students, all of whom have a degree in informatics, one of whom also has a master's degree in the scientific area of the course, and for whom teaching in the area of information and communication technologies (ICT) is nothing new. Teaching professionally mainly with children and young people in the 3rd Cycle of Basic Education and Secondary Education, the challenge is to teach at younger ages, particularly in Pre-school Education and the 1st Cycle of Basic Education. This is the central aim of the Internship in Informatics Education I curricular unit, which adopts a reflective and experimental methodological approach, involving intervention in a pre-school and primary school educational context, totaling 110 contact hours, including observation of educational practices and teaching in real situations.

This work emerges from the activities carried out in this curricular unit during the 1st semester of 2022-2023, in particular those relating to the preparation of the portfolio as an active learning strategy, promoting critical, interventional and argumentative reflection on the observations and teaching carried out during the professionalizing internships. Our aim was to understand how the portfolio facilitated a critical, interventional, and argumentative analysis of the observations and teaching carried out by the students, promoting the acquisition and improvement of the methodological choices made and their impact on the children's learning and the reconstruction of educational action.

Created in web applications, specifically Padlet and Sway, the portfolios created by the students should show the planning of activities, reports, records made during the internship and teaching moments, the instruments used to regulate practice, the resources used, the observations, the children's productions and the photographic records of the activities.

II. The Portfolio as a Constructor of Active Learning

Active learning is a pedagogical model that places the student as the main protagonist of the learning process. In contrast to the traditional passive approach, in which students are mere receivers of information, active learning promotes student participation, encouraging them to seek knowledge, solve problems, work in groups and construct their own knowledge [5]–[7]. According to Smith and collaborators [8], the importance of active student involvement in hands-on activities, such as projects, experiments, and classroom discussions, make active learning an approach that promotes information retention, the development of critical thinking skills and the transfer of knowledge to real-world situations. Duch, Groh and Allen [9], argue that problem-based active learning is an effective strategy to engage students. In this model, students face authentic challenges that prompt them to explore different solutions, work in teams and apply their knowledge in practical contexts. In the studies by Freeman et al. [10], active learning, which involves student participation through discussions, hands-on activities, group collaboration and problem solving, promoted deeper and more lasting understanding of concepts, rather than simply memorising them, and had a significant positive effect on student performance compared to traditional learning.

These active learning strategies provide greater student interaction with the content, stimulating critical thinking, problem solving and practical application of knowledge, making the educational process more dynamic and engaging, in addition to promoting the development of cognitive skills and emphasizing the importance of practical and collaborative activities [1], [8], [10], [11].

The adoption of the portfolio in the curricular unit of Internship in Informatics Education I occurred as a strategy for the promotion of active, critical, and reflective learning, potentially transformative in educational settings [12]-[14]. The option for this resource is based on the view that the portfolio, whether in physical or digital format, is a pedagogical strategy that allows the teacher to monitor and evaluate the evidence of student learning throughout a course or subject, from different perspectives [15]. It serves as a visual record of the work carried out, providing an analysis and evaluation of the actions performed. As a pedagogical tool, it has the potential to provide formative opportunities in various learning situations and in any area of knowledge. It may be used to record a specific content or period, or cover a broader period, such as an entire semester of studies [12], [16], [17].

III. The portfolio As a Tool for Leraning Evaluation

The use of the portfolio as a formative assessment tool has been widely recognised as a valuable approach to assessing students' progress and performance over time, as well as an authentic and contextualised assessment. As students add new evidence to the portfolio, they can receive regular feedback from the teacher and carry out reflections on their own performance. According to Ambrosio [16], the portfolio allows students to demonstrate their skills and competencies in a meaningful way by selecting the best evidence that represents their achievements and progress over time. This provides a more comprehensive view of student performance and allows them to adjust and improvements throughout the learning process.

For Camargo and Daros [15], the portfolio allows students to collect and organize evidence of learning, such as written work, projects, reflections, and records of observations. By selecting the assignments and artifacts to be included in the portfolio, students not only reflect the learning process, but are also encouraged to think critically about their progress, achievements and areas that need improvement. According to Machado, Silva and Sakalauskas [14], writing reflective interpretations in the portfolio, brings multiple benefits to students not only about the learning process, but also, promotes a solid basis for regular feedbacks and metacognitive reflections. Sanchez et al. [17], highlight that the active involvement of students in the selection, organization and reflection on the evidence included in the portfolio promotes engagement, responsibility, and the development of autonomy. Through this process, students become active participants of their own learning, taking responsibility for their progress, and contributing to the continuous improvement of their academic performance. Researchers point out that through the reflections made in the portfolios, students can identify their areas of strength, set learning goals and plan strategies to achieve them. This reflective aspect of the portfolio promotes awareness of one's own cognitive processes and contributes to the development of self-regulation and critical thinking [14]. For Baker, Montenegro, and Jankowski [18], the reflection process promotes metacognition, that is, the awareness of one's own cognitive processes, which can lead to deeper and more autonomous learning. When properly supported, the metacognitive work involved in reflection on the content posted in portfolios can promote greater autonomy of students in their own learning process.

In the curricular unit of Internship in Informatics Education I, the use of the portfolio, in addition to a learning strategy, was also an instrument for a formative assessment, less quantitative and student-centered, able to allow the intervention and guidance of teachers during the process of supervised teaching, focusing on the relevance of the options taken and its impact on children's learning and reconstruction of the educational action. Instead of just making standardized records of the internships made, students were able to present real examples of their observations and the teaching activities carried out, weaving reflections to each evidence published, providing a more comprehensive and contextualized view of their skills and competencies and the learning built.

IV. Methodological Procedures

To ensure the theoretical-practical articulation, we adopted a reflective and experimental methodological approach [19]-[21], with active teaching and learning strategies [1], [9], [10], [15] and a formative assessment modality [22], [23], carried out throughout the academic semester, in order to monitor the students' learning process at each stage of the internship, embodied in the preparation of an individual digital portfolio. The portfolio followed a guided organization presented at the beginning of the course. To the students, they were given the option to choose the application they would like to use to make their portfolios, since they are all informatics teachers and have digital skills and knowledge of several applications. Most students chose Padlet (www.padlet.com) and only one chose Microsoft Sway (https://www.office.com).

Each portfolio would start with an introduction to the course and the students' learning expectations. This would be followed by the publication of the internship sessions, including observations of educational practice and teaching in real contexts. The students were guided to collect as much evidence as possible about the various dimensions of what they achieved during the semester: photographs, drawings, children's productions, activity plans, reports, teaching records, regulation instruments, observations. One of the basic rules was that nothing was simply deposited or kept in the portfolio, as a simple archive of materials, studies, and productions, but that the evidence was like a living instrument of reflective records, written after a meta-analysis of each material apprehended. Thus, for each dimension posted, a critical reflection would be made on the work to be developed and developed, in a logic of, on the one hand, sharing experiences and knowledge and, on the other hand, taking stock of the learning achieved by the children and raising specific formative needs related to pedagogical practice. The students' records were accompanied by each supervising teacher of the internship throughout the process who, by reading the student's productions, visualizes the path of learning and gives feedback with observations and formative directions. For data protection reasons, the portfolios were analyzed in the strict sphere of the teachers who supervised their production, as they contain confidential and sensitive information regarding the identification of the students, the schools where they did their teaching internships and the children with whom they worked, including images.

As previously mentioned, this study involved seven students enrolled in the first year of the master's course, all of whom had a degree in Informatics or a related field (e.g., Computer Engineering), one of whom also had a master's degree in the field, and aged between 26 and 50. Of the seven students, only one had no teaching experience in an educational context at the time.

A. The narrative as a methodological strategy: the portfolios in the Internshipin Informatics Education I

Since the first moment several possibilities were explored, fundamentally oriented towards the construction of a digital portfolio or e-portfolio, for several reasons. First of all, by the nature of the course itself. Considering that this is a Master Couse in Teaching of Informatics, the deepening of knowledge in this area at the service of the trainees, but also thinking about their professional future and the development of their future students, would bring added value as a training instrument and as a mobilization in a professional context.

At the same time, because it allowed a close and regular monitoring of the teacher who was not in permanent physical presence. Its capacity to resize times and spaces, as Loureiro and Meirinhos [24] state, brings with it the possibility that its construction and development may be monitored far beyond the face-to-face meetings between teachers and trainees.

Also and mainly, the potential that these digital tools offer, allowing students to use innovative and creative strategies to record, digitally, intuitively and easily accessible and shared, all the work of design, implementation and evaluation of their performance in the context of pedagogical internship. By allowing audio, video, image and hyperlink resources to be brought together in the same format, together with guidance, construction and reflection documents on the work being developed, it will enable "students to structure the knowledge they have acquired together with research, ...promoting the construction of knowledge of the curricular topic and the development of digital competencies for the use of media" [24, p. 49].

So, in order to build the internship portfolio, which was one of the compulsory assessment tools of the course, the students explored the underlying theoretical assumptions with the teachers, as well as the potential and possible structures that could be adopted, depending on each student's path.

In all, 7 e-portfolios were built, six of them in the Padlet application (Fig. 1 and 2) and one in Sway (Fig. 3), which, throughout the semester, were being developed by students and teachers to, as Do Nascimento and Barbosa [25, p. 33] point out, give the "possibility to reflect, change, expand, relate and negotiate ideas, build new knowledge, making learning something of its own".

Fig. 1. Example of Portfolio built in the Padlet application

Fig. 2. Example of Portfolio built in the Padlet application

Fig. 3. Example of Portfolios built in the Sway application

Starting from a set of general written guidelines offered to the students related to the type of information that could be contemplated and the formal aspects to be respected, the trajectory was also marked by the analysis and discussion of ethical aspects related to the contents to be made available, considering the fact that much of the information to be mobilized concerns children. Once these formal and ethical aspects were overcome, the students began to construct their e-portfolios as the research and documentation relating to the internship was being collected. These general guidelines also served as elements to guide the weekly monitoring and evaluation carried out by the teachers.

Elements such as: a) the presentation of the organization of the portfolio for easy location of information; b) the inclusion of personal aspects related to the functioning of the discipline and their expectations of the internship; c) the inclusion of a roadmap of activities designed and implemented; d) the inclusion of memoranda on positive aspects and aspects to be improved regarding the interventions carried out; e) the provision of in-depth and theoretically supported reflections; and f) the sharing of research or links of interest, were guiding throughout this process.

As the students' competencies in using digital tools were not a problem for them, considering that they all had training in the area of Informatics, the major challenges were related to the selection of the contents to be made available in the e- portfolios and the writing of the various documents, because, as one of them mentioned in his first reflection, they felt "out of context". These difficulties are evident, for example, in one of the portfolios where the more personal aspects related to the students' expectations regarding the subject and their own presentation were not included and where all the other written elements provided were presented in a rather schematic and underdeveloped way, particularly in the documentation regarding the first part of the semester.

Throughout the semester, both in online and face-to-face sessions, the portfolio, its structure and content were analysed, commented on, reflected upon, in order to make students and teachers refocus on the process, to be active participants in it, enabling improvement in whatever is allowed, as stated by Guedes et al. [26].

This joint training process allowed many of the students' difficulties to be progressively overcome. Let us see, for example, a brief reflection made in the memorandum of one of them, in one of the first activities implemented and in one of the last ones:

- "There was a very good participation from the children, and they wanted to listen to the song again at the end" (first memo).

- "I really enjoyed introducing this topic at this grade level (2nd grade), where students are learning to recognise patterns and quantities. I think Machine Learning can help in teaching this topic and in students' learning. According to the Cooperating Teacher the activity was well introduced" (penultimate memo).

From an initial look clearly centred on the children and their interest in the implemented activity, the student moves on to a more comprehensive look, from both a personal perspective and that of the cooperating teacher who accompanies him/her, considering future possibilities of intervention.

In addition to the broader and deeper look that the students were revealing, their writing was also undergoing significant changes in terms of its quality and length. At the same time, most of them shared information, hyperlinks, images and texts which gave an account of the discoveries made, the research carried out and the "inspirations" that each student found on their way.

All these achievements were finally shared in a session that represented the culmination of this first part of the formative journey and where the University's supervisors, cooperative supervisors and students participated. In this session, where each student presented the most significant aspects of their internship, questions were asked and comments made by the participants, enriching, once again, the reflection on the students' journey and the improvement of the portfolio itself. This was, at the same time, the moment to close the evaluation process.

In general, from the teachers' perspective, the e-portfolios proved to be an effective, practical, and appropriate tool for the students' training context, allowing a continuous and close monitoring of the work being developed. However, the tools used by the students conditioned, in some cases, the way the feedbacks were given, particularly the written ones. If in Padlet it is possible to make comments on each of the elements introduced by the students, in Sway the teachers can only read the information which is shared, and it is necessary to download the portfolio in pdf format to make comments or suggestions on the work developed. This situation is an obstacle to the commented reading that can be done by the teachers, so a previous analysis of the different tools available, which allow a formal record of the feedback that is being offered and that, at the same time, allow a transversal reading of that feedback, seems appropriate.

V. Concluding Reflections

The aim of this study was to understand how students and teachers used the portfolio as a learning and assessment tool in the curricular unit of Internship in Informatics Education I of the master's Course in Teaching of Informatics at the University of the Azores, Portugal. With the 2022/2023 academic year being the first year of this master's course, there were 7 students on the course, all of them computer science graduates teaching professionally, mainly with children and young people in the 3rd cycle of basic education. Digital skills were not a problem for these students, but many of the difficulties they encountered at the beginning of the course were due to their distance from pedagogical issues, which are specific to the scientific area of Education, where it is necessary to emphasize the work to be done.

Another difficulty lies in the lack of writing practice that the initial training of these students, as well as their professional career, does not require, creating resistance to the development of more reflective, grounded, and in-depth work. This leads us to consider that the use of the portfolio seems to have added value in terms of the development of writing skills, as well as pedagogical action. It is worth pointing out that we believe that the pedagogical action experienced and reflected on during the internships had a major contribution from the Didactics of Informatics I curricular unit, which ran simultaneously in the same semester, promoting theoretical- practical articulation. This intentional intertwining of these two curricular units in particular may have contributed to a more complete approach, understanding, implementation and evaluation of the students' portfolios. What's more, the evidence presented throughout the development of the content inherent in each portfolio reveals a progressive deepening of pedagogical and didactic issues, indicative of a reflective construction of the profession.

In this sense, the clear focus in terms of training in future editions of this master's will be to continue exploring and using these tools in a contextualized and accompanied way, pedagogically based, promoting student involvement, as Sanchez et al. point out [17][17].

In addition to the benefits for the training processes mentioned above, the digital portfolios represent an added benefit for the completion of the Internship Reports at the end of the second year of the course, as they bring together all the information mobilized and built up during the four internships, as well as the respective evidence of the work carried out, in a format that, quite simply, makes it easier to mobilize the information gathered for the document that will make up the Report.

Considering the added value, it represents for students and teachers, it is essential, also taking into account the results of research such as that by Amante and Gouveia [27] or Rodrigues, Oliveira and Pinto [28], that its continued use is privileged, considering the positive appreciation of this tool as a work, learning and assessment tool. In this sense, it is hoped that in the second semester of the course the construction of the portfolio or its continuation will be made easier, considering the experience that students and teachers have already built up.

In addition to this more formative aspect for the master's students, it is also hoped that this systematic use of the portfolio throughout the course will add value to the work of future Informatics teachers, who will also use the portfolio with their students, from a constructive and reflective perspective of each one's learning

In summary, and taking Amante's [29], p. 231] words, "it is, however, necessary to develop in-depth research on this instrument, namely by identifying good practices inherent to its use". Our objective was, precisely, to make a small contribution to this deeper reflection on the use of the e- portfolio as a valuable instrument for constructive and meaningful learning within teacher training.

Acknowledgment

The authors thank the Interdisciplinary Nucleus of Children and Adolescents - NICA-UAc for the financial support.

References

[1] J. Morán e L. Bacich, Metodologias Ativas para uma Educação Inovadora [Active Methodologies for Innovative Education]. Penso, 2018.

[2] J. Morán, «Mudando a educação com metodologias ativas», em Convergências Midiáticas, Educação e Cidadania: aproximações jovens [«Changing education with active methodologies», in Media Convergences, Education and Citizenship: young approaches, Ponta Grossa: UEPG/PROEX, 2015, pp. 15–33. https://edisciplinas.usp.br/pluginfile.php/4941832/mod_resource/content/1/Artigo-Moran.pdf

[3] A. L. Cortelazzo, D. A. Souza Fiala, D. Piva Junior, L. Panisson, e M. R. J. B. Rodrigues, Metodologias Ativas e Personalizadas de Aprendizagem [Active and Personalised Learning Methodologies]. Alta Books, 2019.

[4] A. C. Loureiro e A. I. Santos, «The pedagogical training of future ICT teachers: an experience report from the University of the Azores», in press de 2023. https://iated.org/concrete3/view_abstract.php?paper_id=105045 (accessed 9 June 2023).

[5] E. Mazur, Peer Instruction: A User's Manual. Prentice Hall, 1997.

[6] L. D. Fink, Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses, Revised and Updated edition. San Francisco: Jossey-Bass, 2013.

[7] E. F. Barkley, Student Engagement Techniques: A Handbook for College Faculty, 1st edition. San Francisco: Jossey-Bass, 2009.

[8] K. A. Smith, S. D. Sheppard, D. W. Johnson, e R. T. Johnson, «Pedagogies of Engagement: Classroom-Based Practices», J. Eng. Educ., vol. 94, n.o 1, pp. 87–101, jan. 2005, doi: 10.1002/j.2168-9830.2005.tb00831.x.

[9] B. J. Duch, S. E. Groh, e D. E. Allen, Eds., The power of problem-based learning: a practical «how to» for teaching undergraduate courses in any discipline, 1st ed. Sterling, Va: Stylus Pub, 2001.

[10] S. Freeman et al., «Active learning increases student performance in science, engineering, and mathematics», Proc. Natl. Acad. Sci., vol. 111, n.o 23, pp. 8410–8415, jun. 2014, doi: 10.1073/pnas.1319030111.

[11] A. A. Fidalgo et al., Metodologias Para Aprendizagem Ativa em Tempos de Educação Digital: Formação, Pesquisa e Intervenção, 1a edição [Methodologies for Active Learning in Times of Digital Education: Training, Research and Intervention, 1st edition]. Paco Editorial, 2021.

[12] A. C. Loureiro e C. Zukowsky-Tavares, «E-Portfolios as Tools for Collaborative Learning on Digital Platforms», Handbook of Research on Comparative Approaches to the Digital Age Revolution in Europe and the Americas, 2016. https://www.igi-global.com/chapter/e-portfolios-as-tools-for-collaborative-learning-on-digital-platforms/www.igi-global.com/chapter/e-portfolios-as-tools-for-collaborative-learning-on-digital-platforms/138031 (acedido 27 de julho de 2022).

[13] A. Sartor Harada, «Avaliação formativa: o portfólio como instrumento de avaliação para o desenvolvimento do aprendizado reflexivo» ["Formative assessment: the portfolio as an assessment tool for the development of reflective learning"], Rev. Meta Aval., vol. 12, n.o 37, p. 826, dez. 2020, doi: 10.22347/2175-2753v12i37.2880.

[14] M. F. R. C. Machado, F. H. Silva, e S. R. Sakalauskas, «As contribuições do portfólio digital como instrumento de avaliação»

["The contributions of the digital portfolio as an assessment tool"], Rev. INTERSABERES, vol. 13, n.o 30, pp. 494–503, fev. 2019, doi: 10.22169/revint.v13i30.1490.

[15] F. Camargo e T. Daros, A Sala de Aula Digital: Estratégias Pedagógicas para Fomentar o Aprendizado Ativo, On-line e Híbrido [The Digital Classroom: Pedagogical Strategies for Promoting Active, Online and Hybrid Learning], 1st edition. Penso, 2021.

[16] M. Ambrosio, O Uso Do Portefólio No Ensino Superior [The Use of Portfolios in Higher Education]. Vozes, 2013.

[17] Sanchez, Kephart, Jones, e des Jardins, «A Methodology to Analyze Self-Reflection in E-Portfolios», em 2020 IEEE Frontiers in Education Conference (FIE), Uppsala, Sweden: IEEE, out. 2020, pp. 1–5. doi: 10.1109/FIE44824.2020.9274281.

[18] G. R. Baker, E. Montenegro, e N. A. Jankowski, «Future directions for prior-learning assessment: Taking essential learning outcomes into consideration», New Dir. Teach. Learn., vol. 2021, n.o 166, pp. 33–42, jun. 2021, doi: 10.1002/tl.20450.

[19] A. V. Reis, «Professores reflexivos: concepções dos supervisores de prática pedagógica: estudo exploratório» ["Reflective teachers: conceptions of supervisors of teaching practice: an exploratory study"], masterThesis, 2006. Accessed: 9 June 2023. [Online]. Available at: https://repositorio.ul.pt/handle/10451/32483

[20] I. Alarcão, Professores reflexivos em uma escola reflexiva, 8a edição [Reflective teachers in a reflective school, 8th edition]. São Paulo, SP: Cortez, 2018.

[21] R. Herdeiro e A. M. C. e Silva, «Práticas reflexivas: uma estratégia de desenvolvimento profissional dos docentes» ["Reflective practices: a strategy for teachers' professional development"], 2008. Accessed: 9 June 2023. [Online]. Available at: http://repositorium.sdum.uminho.pt/

[22] D. Fernandes, «Para uma teoria da avaliação formativa» ["Towards a theory of formative assessment"], Rev. Port. Educ., pp. 21–50, 2006, Accessed: 9 June 2023. [Online]. Available at: https://repositorio.ul.pt/handle/10451/5495

[23] D. Fernandes, «Para um Enquadramento Teórico da Avaliação Formativa e da Avaliação Sumativa das Aprendizagens Escolares» ["Towards a Theoretical Framework for Formative and Summative Assessment of School Learning."], Avaliar Para Aprender Em Port. E No Bras. Perspect. Teóricas Práticas E Desenvolv., pp. 139–164, 2019, doi: 10.24824/978854443463.5.

[24] A. C. Loureiro e M. Meirinhos, «E-Portefólio como recurso para o desenvolvimento de competências digitais», em VIII Conferência Ibérica de Inovação na Educação com TIC: ieTIC2022: livro de atas ["E-Portfolio as a resource for the development of digital skills", in VIII Iberian Conference on Innovation in Education with ICT: ieTIC2022: proceedings book], Bragança, Porugal: Instituto Politécnico de Bragança, 2022, pp. 46–56. doi: 10.34620/ietic.2022.

[25] A. M. Do Nascimento e S. N. F. Barbosa, «Portfólio na formação do pedagogo: memórias e docência na educação infantil» ["Portfolio in the training of pedagogue: memories and teaching in early childhood education"], EDUCA - Rev. Multidiscip. Em Educ., vol. 6, n.o 16, p. 27, dez. 2019, doi: 10.26568/2359-2087.2019.4146.

[26] A. Guedes, S. Antunes, P. Santos, I. Oliveira, e J. Escola, «Os desafios da avaliação e os Portefólios» ["The Challenges of Assessment and Portfolios"], Rev. Pract., vol. 6, n.o 1, pp. 95–109, jun. 2021, doi: 10.24310/RevPracticumrep.v6i1.10160.

[27] L. Amante e C. Gouveia, «O e-portefólio num contexto de aprendizagem online», em Actas da Conferência Internacional ticEDUCA2010 ["The e-portfolio in an online learning context", in Proceedings of the International Conference ticEDUCA2010], Lisboa, Portugal: Instituto de Educação da Universidade de Lisboa, 2010, pp. 408–413. [Online]. Available at: http://ticeduca2010.ie.ulisboa.pt/?page_id=907&lang=pt

[28] M. D. R. Rodrigues, A. L. O. Pires, e J. Pinto, «Utilização de portefólios digitais na formação inicial de professores, como estratégia de aprendizagem e avaliação: perspetivas das estudantes» ["Using digital portfolios in initial teacher education as a learning and assessment strategy: students' perspectives"], Revemop, vol. 4, p. e202209, abr. 2022, doi: 10.33532/revemop.e202209.

[29] L. Amante, «A Avaliação das aprendizagens em contexto online. O e- portefólio como instrumento alternativo», em Aprendizagem (In)Formal na Web Social ["The Assessment of learning in an online context. The e-portfolio as an alternative instrument", in (In)Formal Learning on the Social Web], Braga, Portugal: Centro de Competência Universidade do Minho, 2011, pp. 221–236. [Online]. Available at: https://www.nonio.uminho.pt/wp-content/uploads/2020/09/web_social.pdf

Propuesta de enseñanza de la programación a futuros profesores de Educación Primaria basada en el uso de la Taxonomía de Bloom

A proposal of Teaching Programming to in-service teachers based on the Bloom Taxonomy

Pedro Paredes
Escuela Técnica Superior Ingeniería Informática
Universidad Rey Juan Carlos
Móstoles, Madrid, España
pedro.paredes@urjc.es

Diana Pérez-Marín
Escuela Técnica Superior Ingeniería Informática
Universidad Rey Juan Carlos
Móstoles, Madrid, España
diana.perez@urjc.es

***Abstract*—Para que los futuros profesores de Educación Primaria puedan enseñar programación a sus estudiantes se necesita investigar en la Didáctica de la Programación también a nivel universitario. Este artículo se centra en la enseñanza de la programación con bloques de Scratch en Educación Primaria en el aula universitaria. Se propone usar la taxonomía de Bloom para avanzar desde los niveles más básicos de recordar las instrucciones de Scratch, hasta los niveles más avanzados de ser capaces de crear programas por sí mismos. Esta metodología de enseñanza se valida con una experiencia con 25 estudiantes de primer curso de la asignatura de Informática y Competencia Digital Docente del Grado de Educación Primaria durante el curso 2022/2023. Durante la asignatura los estudiantes aprendieron a enseñar programación avanzando en los niveles de la taxonomía de Bloom registrándose una mejora tanto en la nota final de la asignatura y en sus niveles de motivación y satisfacción. Estos resultados abren el camino para avanzar en el estudio de una Didáctica de la programación también para futuros profesores de Educación Primaria extendiendo los beneficios de la enseñanza temprana de la programación a los estudiantes de Educación Primaria.**

Keywords—enseñanza de la programación; Scratch; taxonomía de Bloom; Educación Primaria

***Abstract*— It is necessary to research into Programming Didactics at the university level if future Primary Education Degree students are to become programming teachers to their students. This article focuses on the teaching of programming with Scratch blocks in Primary Education in the university classroom. It is proposed to use Bloom's taxonomy to advance from the most basic levels of remembering Scratch instructions, to the most advanced levels of being able to create programs. This teaching methodology is validated with an experience with 25 first-year students of the subject of Computer Science and Teaching Digital Competence of the Primary Education Degree during the 2022/2023 academic year. The university students learned how to teach programming by advancing in the levels of Bloom's taxonomy, registering an improvement both in the final grade for the course and in their levels of motivation and satisfaction. These results open the way to advance in the study of Programming Didactics also for future Primary Education teachers, extending the benefits of early programming teaching to Primary Education students.**

Keywords—Teaching programming; Scratch; Bloom Taxonomy; Primary Education

I. Introducción

La enseñanza de la programación en los Grados de Ingeniería Informática es una tarea fundamental [1,2]. Tanto en el caso de lenguajes estructurados como orientados a objetos [3,4]. Dadas las características de los estudiantes universitarios, los objetivos en estos niveles suelen comprender definir y analizar problemas, diseñar un algoritmo para solucionarlo, codificar el algoritmo en algún lenguaje de programación, y ejecutar el código para validar que el programa soluciona el problema indicado. Esto se puede hacer apoyado en el uso del propio ordenador con programas que soporten la enseñanza de la programación [5] o sin necesidad de usar un programa informático con estrategias didácticas como el aprendizaje colaborativo [6].

En los últimos años se han investigado también las ventajas de enseñar programación desde edades tempranas [7-9]. Los niños suelen aprender programación con entornos multimedia como Scratch [10], con robots como Lego WeDo o Mindstorms EV3 [11], o enfoques "unplugged" (sin tecnología) con ejercicios de sitios como Code.org [12].

Aplicar directamente el esquema de enseñanza de la programación de los niveles universitarios a niveles pre-universitarios no parece lo más adecuado debido a las diferentes capacidades de abstracción y procesamiento de los niños.

En nuestro trabajo anterior, hemos publicado una metodología de enseñanza de la programación para niveles pre-universitarios basada en el uso de metáforas [13] capaz de mejorar la capacidad de programar de niños entre 10-12 años. Este trabajo nos ha hecho reflexionar sobre la importancia de enseñar a los futuros profesores de Educación Primaria también a enseñar programación, y centrarnos no tanto en que estos profesores aprendan a programar sino en que aprendan lo que pudiera llamarse una Didáctica de la Programación [14].

En este artículo, se propone el uso de la taxonomía de Bloom [15] como apoyo para esta Didáctica de la Programación. Esto es, ir avanzando desde los niveles más básicos de recordar las instrucciones del lenguaje de programación, en nuestro caso Scratch, hasta los niveles más avanzados en los que los estudiantes ya pueden evaluar y crear programas por sí mismos.

Esta propuesta metodológica se ha llevado a cabo durante el curso 2022/2023 en la asignatura Informática y Competencia Digital Docente del Grado de Educación Primaria de la Universidad Rey Juan Carlos con 70 estudiantes. Los resultados, en el examen final de la asignatura, demuestran que la media obtenida por los estudiantes ha pasado de 7,3 a 7,7 y, según sus respuestas a un test de satisfacción, la metodología les ha motivado y proporcionado actividades que despertaban su curiosidad. Los profesores de la asignatura también han observado que todos los estudiantes han adquirido las competencias necesarias para la enseñanza de la programación por bloques.

El artículo se organiza de la siguiente forma: la Sección 2 revisa el trabajo relacionado; la Sección 3 describe la metodología propuesta; la Sección 4 presenta la experiencia; y finalmente, la Sección 5 termina el artículo con las principales conclusiones.

II. Trabajo relacionado

A. Enseñanza de la programación en Educación Primaria

La enseñanza de la programación a niños comenzó a investigarse en los años ochenta [16]. Sin embargo, esta investigación se pausó en las siguientes décadas principalmente por la complejidad de la enseñanza de la programación y la falta de profesores formados que pudieran impartirla en una asignatura integrada en el currículum escolar de Educación Primaria. Se ha retomado en la última década con el surgimiento de nuevos programas multimedia como Scratch que facilitan la enseñanza de la programación en entornos escolares [10], e iniciativas a nivel mundial de integrar la enseñanza de la programación en el currículum escolar [17,18].

Uno de los enfoques didácticos más utilizados es el construccionismo [19], registrándose la capacidad de los niños de construir programas con piezas de puzzle encajables con Scratch. La Figura 1 muestra un pantallazo de un programa básico creado con Scratch [10].

Como se puede observar en la Figura 1, el programa comienza al pulsar la bandera verde, y tiene 2 instrucciones, la primera de movimiento que hace que el gato se mueva 10 pasos y la segunda de apariencia para que diga "Hola". Se pueden combinar todas las instrucciones de los distintos bloques y ejecutar estas instrucciones sobre el gato u otro objeto aumentando el nivel de complejidad de los programas que se solicite a los estudiantes que vayan realizando.

Las instrucciones en Scratch se agrupan en varias categorías: movimiento, apariencia, sonido, eventos, control, detección, operadores, variables y otros. Cada categoría tiene un color representativo diferente. Cada instrucción está contenida en un bloque con los parámetros en espacios editables. Los niños eligen un bloque con la instrucción y lo arrastran al editor de programas. Los bloques encajan como piezas de un rompecabezas. El programa se ejecuta haciendo doble clic en el programa (es decir, el conjunto de bloques) o haciendo clic en la bandera verde y el resultado se muestra en la pantalla.

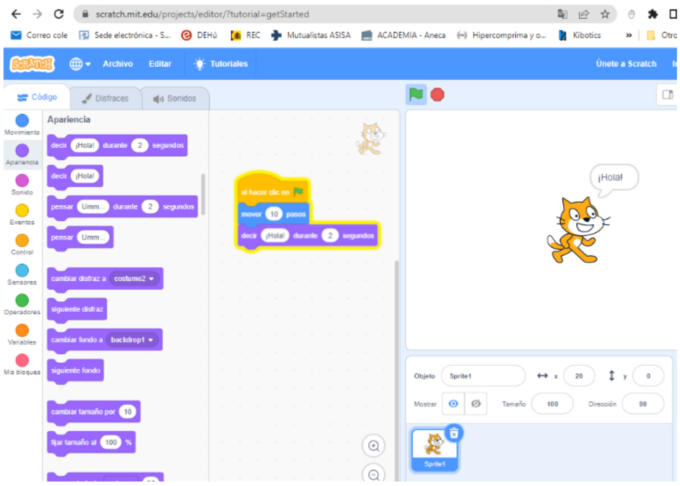


Fig. 1. Pantallazo de Scratch

Scratch es un entorno muy visual orientado a la multimedia con muchas posibilidades como cambiar fondos, configurar los personajes o añadir sonidos. En este entorno, es imposible que los niños cometan errores de sintaxis ya que no escriben instrucciones, solo ingresan el valor de los parámetros en los espacios indicados.

Los niños que utilizan Scratch suelen mostrar actitudes y motivación hacia la programación muy positivas [19]. En todo caso, en la literatura también se han probado enfoques basado en el uso de robots que se mueven como Lego WeDo o Mindstorms EV3 [11], que pueden ir asociados a códigos que se construyen en aplicaciones en tabletas o móviles y al ejecutarlo en lugar de ver en pantalla el resultado del programa, es el robot el que se mueve según lo programado; e incluso enfoques "unplugged" (sin tecnología) en el que los estudiantes no programan usando ordenadores, tabletas, móviles o robots, sino que hacen ejercicios impresos de sitios como Code.org o juegos hablando y escribiendo [12].

Sin embargo, el problema inicial de la falta de profesores formados para enseñar programación persiste y dificulta la introducción de la asignatura de Programación en los niveles pre-universitarios. En la literatura, se encuentran múltiples artículos sobre la Didáctica de la Programación en entornos universitarios [1-6] y sin embargo, se detecta una escasez de artículos relacionados con la didáctica de la programación para futuros profesores de Educación Primaria, limitándose a proporcionar guías basadas en metáforas [13] o al uso de la gamificación con videojuegos educativos [14]. Por lo tanto, se hace necesario seguir investigando en la propuesta de una Didáctica de la Programación para futuros profesores de Educación Primaria.

B. Taxonomía de Bloom

la Taxonomía de Bloom es una lista de objetivos (o niveles) que evalúan el proceso de aprendizaje de cualquier estudiante, además de un punto de partida útil para diseñar de forma lógica actividades y ejercicios y conseguir un aprendizaje significativo que perdure durante toda la vida. Creada en los años 50 por Benjamin Bloom, psicólogo y pedagogo en la Universidad de Chicago, parte de una jerarquía de los objetivos educativos que se busca alcanzar con el alumnado, dividiéndolos en tres ámbitos: cognitivo, afectivo y psicomotor.

Del ámbito cognitivo surge la pirámide de la Taxonomía, que consta de seis categorías con diferentes 'verbos' (acciones que se pueden realizar en cada nivel). Éstos ayudan a evaluar siguiendo una evolución de menor a mayor complejidad en función del proceso cognitivo que requiere un trabajo concreto.

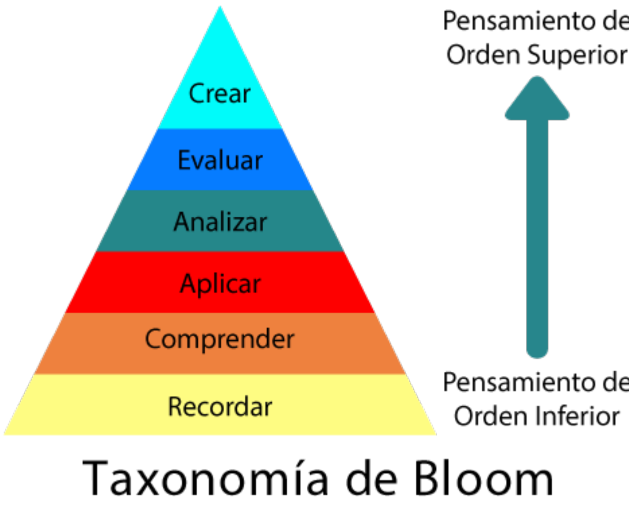


Fig. 2. Taxonomía de Bloom (fuente: Anderson et al. 2001)

Las categorías de la Taxonomía de Bloom han pasado por diferentes cambios para adaptarse a la era digital y, en la actualidad, una de las actualizaciones más aceptadas es la de los investigadores Anderson y Krathwohl (ver Figura 2) que se compone de los siguientes niveles:

- **Recordar:** Es la base a partir de la que se cimenta todo el aprendizaje y hace referencia a la capacidad de recordar hechos específicos, métodos, procesos, esquemas o marcos de referencia a largo plazo.
- **Comprender:** Es la habilidad que tiene el estudiante de saber qué se le está comunicando y requiere de una capacidad de pensamiento abstracto. Se trata de saber interpretar la información y ser capaz de expresarla con palabras propias.
- **Aplicar:** Consiste en poner en práctica los conceptos y procedimientos vistos anteriormente. Implica usar los elementos estudiados en otras situaciones.
- **Analizar:** Se basa en descomponer un problema en partes, considerarlas por separado y descubrir las relaciones que hay entre ellas para, por último, sacar conclusiones.
- **Evaluar:** Se relaciona con la emisión de juicios de valor (cuantitativos y cualitativos) respecto a la información y metodologías recibidas
- **Crear:** Esta categoría fue incluida por los autores y es la más compleja: se basa en utilizar lo aprendido para construir y desarrollar ideas nuevas o en proponer soluciones para problemas del día a día.

En cuanto a la aplicación de la taxonomía de Bloom a la enseñanza de la informática, hay varios estudios que la han intentado aplicar para evaluar a los alumnos, pero ninguno lo ha hecho para establecer una secuencia de actividades adaptadas e los niveles del modelo [20].

III. MÉTODO

En este artículo se propone el uso de la taxonomía de Bloom descrita en la Sección II.B para enseñar a enseñar programación con Scratch a los futuros profesores de Educación Primaria como se describe a continuación.

Tabla 1. Taxonomía de Bloom para la enseñanza de la enseñanza de la programación

Nivel	Tiempo	Objetivo: enseñar a...
Recordar	Primera semana	Memorizar las instrucciones de las categorías Scratch y familiarizarse con la interfaz
Comprender	Segunda semana	Ser capaz de resolver ejercicios básicos de programación
Aplicar	Segunda semana	Ser capaz de resolver ejercicios más complejos de programación
Analizar	Tercera semana	Ser capaz de interpretar programas hechos
Evaluar	Tercera semana	Ser capaz de detectar dónde hay errores en programas hechos
Crear	Cuarta semana	Ser capaz de hacer programas para resolver objetivos propios

En una asignatura de 6 créditos de Informática y Competencia Digital Docente en un Grado de Educación Primaria se podría dedicar un mínimo de un mes a la enseñanza de la enseñanza de la programación. En cada semana un mínimo de 4 horas (por ejemplo, 2 días de 2 horas cada uno). Dada la dificultad de la enseñanza de la programación se recomienda que sea al final de la asignatura cuando los estudiantes ya han ido asimilando el resto de los contenidos y aplicaciones de la materia. La Tabla 1 recoge un resumen de la planificación en niveles de la taxonomía.

Para el primer nivel de **Recordar** se propone comenzar enseñando juegos para que los estudiantes de Educación Primaria aprendan la interfaz de Scratch a los estudiantes. Inicialmente se enseñaría la interfaz a los estudiantes universitarios para que puedan visualizar las posibilidades de Scratch y dónde encontrar cada instrucción según su tipo.

Posteriormente, se pueden hacer juegos con los distintos colores de las instrucciones para amenizar la enseñanza a los niños de Primaria. Por ejemplo, dividiendo la clase en equipos de colores, y cada equipo que se encargue de recitar instrucciones al resto. Así, podría empezar el equipo azul recitando al resto de la clase las instrucciones de secuencia, a continuación, el equipo amarillo que recita las instrucciones de eventos, y así hasta que toda la clase recuerde las instrucciones de programación.

Para el segundo y tercer nivel de **Comprender y Aplicar** se propone proporcionar a los estudiantes un listado de ejercicios, clasificado por conceptos de programación que tienen que comprender como son entrada/salida, condicionales y bucles, para que los estudiantes universitarios primero sean capaces de comprender cómo resolver ellos los ejercicios y posteriormente poner en común en clase cómo este mismo listado podría ser resuelto por los estudiantes de Educación Primaria. La Figura 3 muestra un ejemplo de ejercicios para comprender el concepto de condicional.

EJERCICIOS DE PROGRAMACIÓN CON SCRATCH

Condicionales

Ejercicio 1. Escribe el programa para que poder escribir por pantalla de qué fruta tienes más, si peras o manzanas.

Ejercicio 2. Decir cuál es el mayor de dos números.

Ejercicio 3. Tengo la nota de mi examen. Si es menor que 5 el gato me tiene que decir que estoy suspenso. Si es mayor que 5, tiene que decirme que es notable si está entre 5 y 8, y me tiene que decir sobresaliente si es mayor o igual que 8.

Fig. 3. Ejemplo de ejercicios para el segundo y tercer nivel

Para el cuarto y quinto nivel de **Analizar y Evaluar** se propone proporcionar programas hechos a los estudiantes universitarios que deben ser capaces de entender, comparar, y detectar si tienen errores para solucionarlos primero ellos, y así empatizar con la situación futura en la que serán sus futuros estudiantes de Educación Primaria los que se tengan que enfrentar a la misma situación con su ayuda. La Figura 4 muestra un ejemplo de ejercicios para estos niveles.

Ejercicio 2

Apertura: martes, 28 de marzo de 2023, 11:00
Cierre: lunes, 10 de abril de 2023, 23:59

Marcar como hecha

Carga estos proyectos de Scratch y comprueba las diferencias entre ellos. ¿Cuál es mejor y por qué?

Entrega un documento word o pdf con las diferencias y tu respuesta a la pregunta.

Ejemplo - diálogo 1.sb3 27 de marzo de 2023, 16:06
Ejemplo - diálogo 2.sb3 27 de marzo de 2023, 16:06

Fig. 4. Ejemplo de ejercicio para el cuarto y quinto nivel

Por último, para el nivel de **Crear** que es el que requiere un pensamiento de orden más superior a los estudiantes universitarios se les debe dar a elegir un tema a enseñar a sus futuros estudiantes de Educación Primaria usando Scratch y que sean ellos los que decidan qué programa crear para conseguir el objetivo que ellos mismos se marquen. Esto permitirá que en sus futuras clases transmitan a sus estudiantes también la idea de que Scratch y programar en general no se limita únicamente a resolver ejercicios que les plantean los profesores, sino que en última instancia el objetivo es que ante cualquier problema que ellos mismos se planteen lo puedan solucionar creando un nuevo programa. Además, a los estudiantes universitarios se les pide que graben en grupo un vídeo explicando los conceptos de programación para evaluar también su capacidad de expresión oral como se muestra en la Figura 5.

Actividad grupal de Scratch I

Marcar como hecha

Tenéis que entregar un archivo comprimido, por grupo, que incluya:

- Un pdf con la descripción de la actividad propuesta (del tema elegido para el proyecto final): objetivo, metodología, materiales,...
- El programa tiene que tener un mínimo de 2 personajes, fondo, 2 instrucciones de entrada/salida, 1 condicional, 1 bucle, 1 diálogo y mínimo 20 líneas por personaje.
- Un video corto en el que se vea la ejecución del programa de Scratch.
- El archivo del proyecto .sb3

Actividad grupal de Scratch II

Marcar como hecha

Tenéis que realizar un vídeo explicativo de algún concepto básico de programación: secuencia, algoritmo, variable, condicional, bucle. Teniendo en cuenta que el público objetivo son vuestros alumnos, los conceptos deberán ser explicados de forma amena y concisa. También debéis tener en cuenta que los vídeos sean accesibles para todos, os dejamos un enlace donde podéis ver una breve explicación https://www.exactas.unlp.edu.ar/uploads/docs/recomendaciones_cced.pdf.

Fig. 5. Ejemplo de ejercicio para el sexto nivel

IV. EXPERIENCIA

C. *Muestra*

El método propuesto de enseñanza a los estudiantes universitarios para enseñar programación a los estudiantes de Educación Primaria se aplicó durante el curso 2022/2023 en el primer curso del Grado de Educación Primaria en la asignatura de Informática y Competencia Digital Docente a los 70 estudiantes matriculados en la asignatura. No obstante, cuando se solicitó que completasen un formulario con su opinión de forma anónima y voluntaria, solo 25 lo completaron que será la muestra con la que trabajaremos para los datos recogidos.

El 56% de los estudiantes tienen entre 18-19 años (a excepción de 4 estudiantes, 16%, que tienen entre 17-18 años y 7 estudiantes, 28%, que tienen más de 19 años). El 64% de los estudiantes son hombres frente al 36% que son mujeres. El 76% de los estudiantes ya conocían Scratch de su formación previa.

D. *Procedimiento*

En enero 2022 comenzó la asignatura de Informática y Competencia Digital Docente que es del segundo cuatrimestre y dura hasta mayo 2022. Siguiendo el método descrito en el tercer apartado se dedicó el mes de abril y una semana de mayo (puesto que entre medias era Semana Santa y hubo unos días no lectivos) para seguir la planificación mostrada en la Tabla 1.

Al final de la asignatura se pidió a los estudiantes que completaran un cuestionario[1] de forma anónima y voluntaria para conocer el grado de satisfacción con la forma en que habían aprendido a enseñar programación en Educación Primaria. Se decidió utilizar un cuestionario ad hoc puesto que no se encontró ninguna otra opción validada, que abarcara las preguntas de los datos que era necesario recopilar para conocer el grado de satisfacción de los estudiantes con el nuevo método de enseñanza aplicado durante el curso.

El cuestionario creado constaba de 15 preguntas, las tres primeras para registrar su edad, sexo y si conocían Scratch previamente y conocer la muestra del estudio; las 11 siguientes preguntas de elección múltiple con posibilidad de elegir solo una respuesta para conocer su opinión sobre qué le ha parecido los programas realizados, y su grado de satisfacción.

[1] El cuestionario se puede encontrar en https://tinyurl.com/ycebh2pr

Para animar a los estudiantes a completar todo el cuestionario, tarea que no suele agradarles y debido al carácter voluntario de la actividad, se decidió usar escalas de estrellas en algunas preguntas para evitar que todas las preguntas tuviesen respuestas tradicionales tipo Likert, verdadero/falso, si/no y aportar variedad. La última pregunta se dejó abierta y sin obligación de completar únicamente para recoger cualquier otro aspecto que los estudiantes pudiesen querer añadir libremente.

E. Resultados

La Figura 6 muestra el principal resultado de la satisfacción de los estudiantes con la forma en que han aprendido a enseñar programación siendo una puntuación de 4.1 en una escala de 0 (peor) a 5 (mejor) con una desviación típica de 0,88. El 64% de los estudiantes consideran que aprender a enseñar programación de esta forma les ha resultado satisfactorio y un 24% consideran que ha sido muy satisfactorio. Un 88% además indica que le ha gustado aprender a enseñar a programar con Scratch.

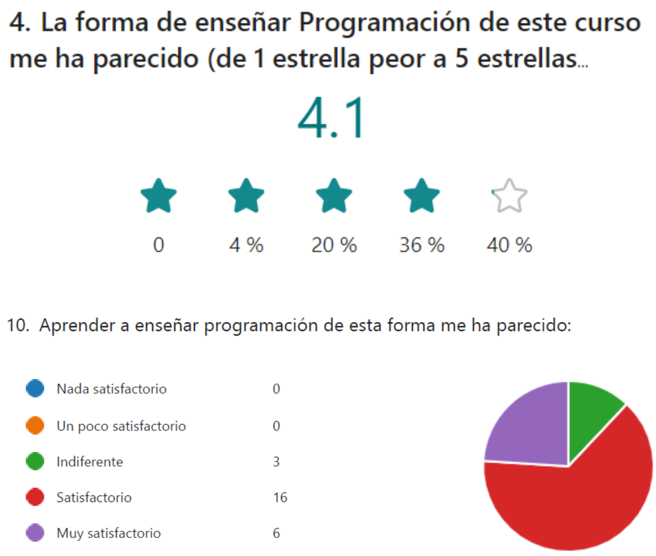


Figura 6. Nivel de satisfacción de los estudiantes

Tabla 2. Porcentaje de estudiantes que consideran que se ha completado cada nivel de la taxonomía de Bloom según las respuestas proporcionadas en el cuestionario

Nivel	Pregunta	%
Recordar	La realización de la hoja de ejercicios me ha parecido útil o muy útil	88
Comprender y Aplicar	Creo que los ejercicios me han ayudado a saber qué instrucciones debo usar	100
Analizar y Evaluar	Ver programas ya hechos en Scratch me ha parecido útil o muy útil	96
Crear	Tener que hacer yo programas en Scratch relacionados con mi proyecto de programación me ha parecido útil o muy útil	92

Este alto nivel de satisfacción puede deberse a que los estudiantes han encontrado cubiertos todos los niveles de la taxonomía de Bloom como se muestra en la Tabla 2. Cuando se pregunta a los estudiantes qué consideran que ha sido lo más difícil de aprender a enseñar programación, la mayoría – un 68% - indica que ha sido la secuencia de instrucciones.

Por último, cuando se recogen comentarios libres que voluntariamente quieren aportar los estudiantes proporcionan respuestas de este estilo:

- *"La parte de Scratch me ha parecido muy útil para poder introducir la programación a los niños en esta era tecnológica."*
- *"Considero que el aprendizaje de Scratch nos ha servido como ejemplo para realizar actividades con los alumnos"*
- *"Me ha gustado la forma en la que se ha empleado Scratch, como una visión general para poder emplear esa herramienta en nuestro futuro como docentes"*

En cuanto al rendimiento académico de los estudiantes, se ha visto un incremento significativo en la nota media obtenida en la asignatura, que ha pasado de 7,3 a 7,7, en una escala que va del 0 al 10.

V. CONCLUSIONES

La enseñanza de la programación en Educación Primaria ha generado un gran interés en las últimas décadas. En este artículo, el foco se ha puesto en cómo enseñar a enseñar programación a los futuros docentes en los Grados de Educación Primaria. Se ha propuesto el uso de la taxonomía de Bloom cubriendo desde los niveles más básicos de recordar hasta crear, en una experiencia con los estudiantes de Informática y Competencia Digital Docente del Grado de Educación Primaria de la Universidad Rey Juan Carlos en el curso 2022/2023. Los resultados obtenidos parecen indicar que este acercamiento didáctico podría ser beneficioso para los estudiantes puesto que ha obtenido altos niveles de satisfacción

- Puntuación de 4.1 en una escala de 1 a 5 estrellas
- 88% de los estudiantes indicando que les ha parecido una experiencia docente satisfactoria o muy satisfactoria e indican que les ha gustado aprender a enseñar de esta forma Scratch a sus futuros estudiantes.

Además, el 100% de los estudiantes ha obtenido una calificación superior a 5 en el examen realizado, y la media ha sido de 7,7 (4 décimas por encima del año pasado). Cabe destacar también que ningún estudiante abandonó la asignatura, esto puede ser debido a la metodología empleada y al alto grado de satisfacción de los estudiantes con ella.

Como trabajo futuro se quiere seguir investigando en las metodologías docentes más adecuadas para enseñar a enseñar programación a futuros docentes y se anima a la comunidad científica a aportar más trabajos en esta línea.

AGRADECIMIENTOS

Trabajo realizado dentro del marco del proyecto P2018/TCS-4307 que además ha sido cofinanciado por los fondos estructurales FSE y FEDER.

REFERENCIAS

[1] R. Satorre Cuerda, F. Llorens Largo, J.A. Puchol García. "Enseñar Programación en las Ingenierías Informáticas". II Jornadas Nacionales de Innovación en las Enseñanzas de las Ingenierías, Instituto de Ciencias de la Educación, Universidad Politécnica de Madrid, diciembre de 1996. Comunicaciones Volumen II, pág. 840-847, 1996.

[2] J.M. Cordero, R. González, R. Romero, R. Martínez. "Introducción a la programación, un enfoque práctico", Algaida, 1996.

[3] I. Fernández Muñoz, R. Peña, F. Nava, A. Velázquez Iturbide. "Análisis de las propuestas de la enseñanza de la programación orientada a objetos en los primeros cursos". VIII Jornadas de Enseñanza Universitaria de la Informática, 433-440, 2002.

[4] I. Kereki. "Enseñando y Aprendiendo Programación Orientada a Objetos en los primeros cursos de Programación: la experiencia en la Universidad ORT Uruguay". Universidad ORT Uruguay, Uruguay. https://silo.tips/download/enseando-y-aprendiendo-programacion-orientada-a-objetos-en-los-primeros-cursos-d , 2017.

[5] R. Pérez Calderón. "Una herramienta y técnica para la enseñanza de la programación". CICos, 229-239, 2008.

[6] O. Revelo Sánchez, C.A. Collazos Ordoñez, J. A. Jiménez Toledo. "El trabajo colaborativo como estrategia didáctica para la enseñanza/aprendizaje de la programación: una revisión sistemática de literatura". TecnoLógicas, vol. 21, no. 41, pp. 115134, 2018.

[7] Computer Science Teachers Association (CSTA). "Computer Science K–8 Building a Strong Foundation", http://csta.acm.org/Curriculum/sub/CurrFiles/CS_K8_Building_a_Foundation.pdf. 2012.

[8] H. Jacobsen. "Five-years-old learn coding in schools to prepare for future labour market". EurActiv.com - EU News & policy debates, across languages, 2014.

[9] J. Hromkovič, D. Komm, R. Lacher, and J. Staub. "Teaching with LOGO Philosophy". Encyclopedia of Education and Information Technologies, A. Tatnall (ed.), Springer Nature, https://doi.org/10.1007/978-3-319-60013-0_76-1, 2019.

[10] M. Resnick, J. Maloney, A. Monroy-Hernandez, N. Rusk, E. Eastmond, K. Brennan. "Scratch: Programming for all". Communications of ACM, 12, 52(11), pp. 60-67, 2009.

[11] N. Zygouris, A. Striftou, A. Dadaliaris, G. Stamoulis, A. Xenakis, and D. Vavougios. "The use of LEGO Mindstorms in elementary schools". EDUCON, 514-516, doi:10.1109/EDUCON.2017.7942895, 2017.

[12] C. Brackmann, D. Barone, A. Casali, R. Boucinha, S. Muñoz-Hernandez. "Computational thinking: Panorama of the Americas". Presented at Computers in Education (SIIE), pp. 1-6, IEEE, 2016.

[13] D. Pérez-Marín, R. Hijón-Neira, A. Bacelo, C. Pizarro. "Can computational thinking be improved by using a methodology based on metaphors and scratch to teach computer programming to children?". Computers in Human Behavior, 105, 105849, 2020.

[14] I. Cruz-García, J.A. Martín-García, D. Pérez-Marin, C. Pizarro. "Propuesta de didáctica de la Programación en Educación Primaria basada en la gamificación usando videojuegos educativos". Education in the Knowledge Society (EKS), 22, e26130-e26130, 2021.

[15] L.W. Anderson, D.R. Krathwohl, P.W. Airasian, K.A. Cruikshank, R.E. Mayer, P.R. Pintrich, R. Raths, M.C. Wittrock. "Taxonomy for Learning, Teaching and Assessing. A Revision of Bloom's Taxonomy of Educational Objectives", Addison-Wesley Longman: Nueva York, NY, 2001.

[16] S. Papert, Mindstorms: Children, computers, and powerful ideas. New York, NY: Basic Books, 1980.

[17] F. Heintz, L. Mannila, T. Färnqvist, "A review of models for introducing computational thinking, computer science and computing in K-12 education", IEEE Frontiers in Education Conference, 2016, pp. 1-9.

[18] R. Hijón-Neira, L. Santacruz-Valencia, D. Pérez-Marín, M. Gómez-Gómez. "An analysis of the current situation of teaching programming in Primary Education". In 2017 International Symposium on Computers in Education (SIIE) (pp. 1-6). IEEE, 2017.

[19] S. Papavlasopoulou, M. N. Giannakos, L. Jaccheri. "Exploring children's learning experience in constructionism-based coding activities through design-based research", Computers in Human Behaviour, DOI: 10.1016/j.chb.2019.01.008, 2019

[20] S. Masapanta-Carrión and J. Á. Velázquez-Iturbide. "Una Revisión Sistemática del Uso de la Taxonomía de Bloom en la Enseñanza de la Informática", SIIE 2017, pp. 294-299

Formação Pedagógica de Professores do Ensino Superior: Comunicação e Colaboração com Tecnologias Digitais

Ana Luisa de Oliveira Pires
Instituto Politécnico de Setúbal – Escola Superior de Educação
CICS.NOVA
Lisboa, Portugal
http://orcid.org/0000-0001-9680-4051

Maria do Rosário Rodrigues
Instituto Politécnico de Setúbal – Escola Superior de Educação
CIEF
Setúbal, Portugal
http://orcid.org/0000-0002-9935-6917

***Abstract*—Este artigo tem como finalidade refletir sobre uma estratégia de formação pedagógica de professores do Ensino Superior (ES), orientada para o desenvolvimento de competências de comunicação e colaboração com recurso a tecnologias digitais. A formação, destinada aos professores de uma instituição pública de ES em Portugal, foi concebida e implementada nos anos letivos de 2020/2021 e de 2021/2022, a partir dos contributos de um projeto Erasmus+, finalizado em 2021. Utilizando a metodologia de investigação-ação e destacando a dimensão de reflexão sobre as práticas, as autoras apresentam os pressupostos teóricos que enquadram a formação e a estratégia desenvolvida, refletindo sobre os seus contributos para o desenvolvimento profissional docente, a partir da avaliação dos formandos e das suas reflexões.**

Keywords—Desenvolvimento profissional, tecnologias, colaboração, comunicação

I. Introdução

A formação pedagógica dos professores do Ensino Superior (ES) tem assumido um papel determinante no desenvolvimento profissional docente e na mudança das práticas educativas, tendo vindo a constituir-se como um novo campo de práticas e de estudos em Educação. No entanto, ainda se constata a escassez de trabalhos de investigação neste domínio, particularmente a nível nacional. Assim, pretendemos com este artigo enriquecer a reflexão neste campo, trazendo alguns contributos para a discussão, a partir da análise de uma estratégia desenvolvida com docentes de uma instituição pública de ensino superior português. O estudo, enquadrado na metodologia da investigação-ação, tem como foco a implementação e avaliação de uma estratégia de formação pedagógica de docentes, com a finalidade de promover o desenvolvimento de competências de comunicação e de colaboração com recurso às tecnologias digitais. Esta formação decorre da experiência desenvolvida pelas autoras, no âmbito de um projeto realizado nos anos de de 2018 a 2021 (Project ERASMUS+ KA2: "The system of support for academic teachers in the process of shaping soft skills of their students" - *SoftSkills*) realizado em colaboração com cinco instituições de países europeus. No âmbito desse projeto, foi realizado um inquérito por questionário aos docentes das quatro instituições europeias envolvidas [1], cujos resultados evidenciaram a existência de um leque diversificado de necessidades de formação, entre as quais se destacaram: a) questões relacionadas com o papel do professor no processo de aprendizagem dos estudantes e a utilização de estratégias pedagógicas adequadas (abordagens participativas, colaborativas, trabalho autónomo,...), incluindo a avaliação formativa e sumativa; b) estratégias para o desenvolvimento de *softskills* dos estudantes — como o pensamento crítico, a criatividade, inovação, trabalho em equipa, entre outros; c) abordagens e estratégias que permitam trabalhar com grupos interculturais, face à crescente diversidade cultural no E.S.; d) a utilização de tecnologias digitais no processo de ensino e aprendizagem dos estudantes, com um enfoque particular nos aspetos colaborativos da aprendizagem. Ainda no âmbito desse estudo, foi desenvolvida uma experiência-piloto de construção de um curso modular intitulado "Utilização das tecnologias digitais no processo de ensino aprendizagem", durante o ano letivo de 2020/2021 [2], o que permitiu um aprofundamento da reflexão sobre os desafios inerentes à formação pedagógica dos docentes no ES.

Sabendo que a rápida evolução das tecnologias digitais no ES tem um forte impacto ao nível da construção de ambientes pedagógicos inovadores [3], e que as tecnologias facilitam o acesso à informação e à comunicação/interação quer entre estudantes, quer entre professores, quer ainda entre estudantes e professor, estamos conscientes que "não é possível pensar a educação e os professores sem uma referência à tecnologia e à sua "virtualidade" [4, p. 35]. Por outro lado, há que ter em atenção os desafios com que os docentes se confrontam, particularmente "a reprodução à distância" das aulas, ou a "ilusão" de que as tecnologias são neutras que trazem soluções "prontas-a-usar" [4, p. 36]. Uma oferta de formação pedagógica que responda às necessidades dos profissionais do ensino superior deve ser sempre co-construída com os docentes, considerados como os principais autores da sua prática, valorizando as comunidades de aprendizagem colaborativa [5]. A formação pedagógica, a inscrever numa lógica de desenvolvimento profissional [5],[6] deverá observar um conjunto de características, entre as quais destacamos a articulação com as necessidades de formação, adesão voluntária, valorização institucional, referenciais teóricos credíveis em articulação com a prática, mobilização de saberes adquiridos, flexibilidade, entre outros [6].

II. Enquadramento Teórico

A. *A necessidade do trabalho colaborativo no ES*

Tradicionalmente a profissão docente tem sido marcada pela cultura de individualismo, decorrente de aspetos históricos e organizacionais: "A maioria dos professores resiste tanto à objetivação dos seus atos profissionais através da pesquisa, quanto à análise cooperativa das suas práticas entre colegas" [7, p. 96]. Reconhecendo-se a dificuldade que professor tem em mudar as situações e os contextos de trabalho de forma isolada, devido a um "exercício solitário do docente" [8, p. 18], há que repensar estratégias de formação que sejam adequadas à construção de comunidades de aprendizagem, permitindo ultrapassar as dificuldades e promover o desenvolvimento profissional docente.

Mais recentemente, as mudanças de nível político, cultural e organizacional que têm ocorrido no ES têm contribuído para a criação de equipas multidisciplinares, levando à identificação de problemas comuns e à construção de comunidades de prática, que criam oportunidades para a troca de experiências, reflexão e discussão entre pares. E, ainda, há que considerar a evolução da tecnologia e a evolução dos perfis dos estudantes, que também têm contribuído de forma significativa para a mudança das práticas educativas.
Estamos conscientes da necessidade de construção de ambientes educativos para o desenvolvimento de práticas colaborativas, assentes na comunicação aberta e no diálogo, baseadas numa pedagogia do encontro [4, p. 47] — para quem a colaboração é uma garantia para a "ética da profissionalidade docente". Assim, através da construção de um programa de formação pedagógica de professores, procuramos contribuir para a melhoria das práticas pedagógicas dos docentes e para o reforço de uma cultura profissional assente na colaboração.

B. Conceitos de colaboração e aprendizagem colaborativa

Para a conceção do programa de formação mobilizámos um quadro teórico construído em torno dos conceitos de colaboração, comunicação e aprendizagem colaborativa, que passamos a enunciar. Colaboração significa trabalhar em conjunto, partilhando objetivos e processos, com intenção explícita de produzir valor [9]; diz respeito a uma atividade síncrona, contínua e coordenada, baseada numa conceção partilhada de um problema [10]; as tarefas são mais complexas e os grupos organizam-se livremente, assumindo mais poder [10]. No ensino superior, a colaboração pode desenvolver-se entre pares — como, por exemplo, entre professores, entre investigadores ou entre estudantes —, ou entre atores com estatutos e papéis diferenciados — como é o caso de professores e investigadores, ou ainda professores e estudantes [11]. Entende-se como trabalho colaborativo aquele que se desenvolve em torno de uma finalidade comum, no qual os participantes assumem uma diversidade de papeis, a liderança é participativa, existe diálogo e partilha de informação, todos os elementos são co-responsáveis pelo processo e resultados, a tomada de decisão é conjunta. "O trabalho colaborativo estrutura-se essencialmente como um processo de trabalho articulado e pensado em conjunto, que permite alcançar melhor os resultados visados, com base no enriquecimento trazido pela interação dinâmica de vários saberes específicos e de vários processos cognitivos" [12, p. 27]. O conceito de aprendizagem colaborativa remete para a aquisição de conhecimentos, competências ou atitudes que ocorrem em resultado da interação em grupo, ou aprendizagem individual como resultado do processo em grupo [9]. O conhecimento é construído de forma participada, através do diálogo e da discussão, e implica a reflexão e a compreensão de conceitos e/ou técnicas de reflexão. Os benefícios dos ambientes colaborativos são geralmente identificados em termos de qualidade de aprendizagem, exploração de experiências e capacidades, maior nível de motivação para as tarefas, reforço da relação com os pares (sejam estes docentes ou estudantes). Os resultados das práticas e de ambientes colaborativos traduzem-se geralmente em produtos ou em experiências de aprendizagem que vão mais além do que da soma de contribuições individuais [13].

C. Colaboração com recurso às tecnologias digitais

O Quadro Europeu de Competência Digital para Educadores (DigCompEdu) [14] foi criado no âmbito da União Europeia, tendo por base o reconhecimento que os educadores necessitam de desenvolver um conjunto de competências digitais específicas para a sua profissão, que lhes permitam aproveitar o potencial das tecnologias digitais, com vista a melhorar e inovar a educação. Este quadro europeu organiza as competências específicas da profissão em três grandes grupos: as competências profissionais dos educadores, as competências pedagógicas dos educadores e as competências dos estudantes. Em todos estes grupos, a colaboração é uma competência referida. No que se relaciona com as competências profissionais, considera-se o uso das tecnologias para "partilhar e trocar conhecimento e experiência, bem como para inovar práticas pedagógicas de forma colaborativa" [14, p. 19]. No âmbito das competências pedagógicas, sugere-se o uso das tecnologias digitais "enquanto parte de tarefas colaborativas, como meio de melhorar a comunicação, a colaboração e a criação colaborativa de conhecimento." [14, p. 21]. Finalmente no que se relaciona com as competências dos estudantes, refere-se que se devem "Incorporar atividades, tarefas e avaliações de aprendizagem que requeiram que os aprendentes usem, eficaz e responsavelmente, tecnologias digitais para comunicação, colaboração e participação cívica" [14, p. 23].

Para proporcionar utilização das tecnologias em processos de colaboração, existem diversas plataformas que facilitam a criação, alteração e partilha colaborativa de documentos e apresentações [15]. Algumas permitem trabalho assíncrono (por exemplo o *Moodle*, o *Google Meeting*, o *Canvas LMS* ou o *Blackboard*) e não exigem que a colaboração seja efetuada pelos participantes num mesmo tempo, uma vez que as interações podem ocorrer em tempos diferidos. Assim, o tempo que medeia entre a publicação de uma mensagem e a respetiva resposta proporciona oportunidades de reflexão e de trabalho, de acordo com as características e disponibilidade de cada participante. Por outro lado, as plataformas que permitem trabalho síncrono, como por exemplo os sistemas de videoconferência, suportam comunicação vídeo nos dois sentidos e a partilha de ecrã, permitindo que a interação ocorra ao mesmo tempo, sem necessidade de deslocações.

Estes ambientes digitais contribuem para o efeito de igualdade com esbatimento de indicadores de estatuto social e consequente diminuição de dinâmicas de poder. Estes aspetos podem promover a participação ativa dos estudantes e destes com o professor [16], tornando as aprendizagens mais significativas. A participação em ambientes *online* oferece oportunidades mais igualitárias de expressão, independentemente de estrato económico e social, género, raça, riqueza ou aparência. A maioria dos estudos sobre esta temática, no entanto, testou o efeito de igualdade por meio da comunicação textual, que se mostrou diferente da igualdade em interações *online* por meio de vídeo [16].

Os ambientes de aprendizagem colaborativa com recurso às tecnologias apresentam vários desafios, de entre os quais se destaca a necessidade de uma atitude ativa e a adaptação a um ambiente diferente do tradicional, onde o estudante geralmente tem um papel passivo de ouvinte [15]. No que diz respeito aos aspetos positivos, destaca-se o desenvolvimento pessoal, o desenvolvimento de estratégias colaborativas e competências socioemocionais [16].

III. METODOLOGIA

O estudo realizado é de natureza qualitativa [17], [18] e reflete a perspetiva do professor investigador, enquanto um profissional reflexivo que estuda a sua própria prática [19]–[22]. A importância da investigação sobre a própria prática contribui para a clarificação e resolução de problemas educativos, para o desenvolvimento profissional dos professores, para a melhoria das organizações onde se inserem e ainda para o desenvolvimento da cultura profissional [20], [21]. A lógica subjacente a esta abordagem — da identificação e compreensão do problema, do agir para transformar e melhorar as práticas educativas — segue os princípios da Investigação-Ação [23], ancorada em práticas investigativas realizadas nos contextos de ação, de forma reflexiva, crítica, colaborativa e cíclica. O presente estudo desenvolveu-se em 4 fases distintas:

1. Conceção e planificação do curso – construção da ação de formação: definição de objetivos, desenvolvimento das estratégias pedagógicas, identificação dos recursos, construção dos procedimentos de avaliação, organização das sessões e dos instrumentos de recolha de informação;

2. Implementação da formação — ocorreu em dois anos letivos consecutivos (2020/21 e 2021/22), com dois grupos distintos de formandos;

3. Avaliação da formação (processo e resultados) — recolha de informação através da observação direta dos participantes e das sessões, realizada pelas formadoras; reflexões escritas de carater qualitativo produzidas pelos formandos no final da ação de formação; inquérito por questionário realizado pelos formandos no final da ação de formação;

4. Reflexão sobre o ação e futuro planeamento — análise das observações das formadoras sobre as sessões de formação; análise das reflexões escritas produzidas pelos formandos e das respostas aos questionários.

Para efeitos de recolha e tratamento de informação, de forma a garantir o anonimato, a cada participante foi atribuído um código. Nas citações das reflexões, foi referido também o ano em que o formando participou na ação de formação decorreu (2020/21 e 2021/22).

IV. CARACTERIZAÇÃO DA FORMAÇÃO

A ação de formação Comunicação e Colaboração em Meios Digitais foi incluída no plano de formação da instituição de ensino superior (IES), sendo a inscrição de carater voluntário, através de plataforma *online*, após divulgação pelos canais de comunicação interna da IES.

Esta formação foi desenhada de acordo com as necessidades identificadas no projeto *The system of support for academic teachers in the process of shaping soft skills of their students* [1] e que foram consideradas pertinentes para o desenvolvimento profissional dos docentes, bem como para o desenvolvimento organizacional da IES.

Os objetivos da ação de formação visam promover a discussão e a experimentação de processos de comunicação entre pares que, apoiados pelas tecnologias digitais, possam conduzir à construção de ambientes de partilha e de aprendizagem colaborativa.

A ação de formação ocorreu após o término das aulas do segundo semestre, numa fase em que os docentes já terminaram o trabalho letivo e na qual se previa uma maior disponibilidade para a formação.

Optou-se por um modelo de formação *online*, considerando que os docentes acumulam a formação com todas as outras atividades profissionais, evitando assim deslocações que sobrecarregassem o tempo que os professores dedicam à formação. Para além deste aspeto, a formação *online* permite uma maior flexibilidade, visto que os formandos podem participar no trabalho assíncrono de acordo com as suas disponibilidades e as modalidades de trabalho e reflexão se adequem às suas características pessoais [15].

Para o desenho da formação *online* optamos por um modelo baseado na participação e interação dos formandos, com um número total de quinze horas de trabalho, das quais quatro são síncronas, através da plataforma *Zoom*, e as restantes são dedicadas ao trabalho autónomo com os recursos disponibilizados, assim como ao desenvolvimento de atividades colaborativas por parte dos formandos.

Nos dois anos académicos em que a ação decorreu (2020/21 e 2021/22), contou com a mesma equipa de formadoras (as autoras do estudo) e com a participação de nove formandos, docentes provenientes de quatro das cinco escolas da IES.

A ação de formação integra, nas suas dinâmicas pedagógicas, os princípios e pressupostos teóricos que foram apresentados no ponto II-B [9]-[13], relativos à colaboração e à aprendizagem colaborativa, assentes em estratégias de liderança participativa, comunicação aberta, dialogicidade, discussão crítica e reflexividade, articulando saberes teóricos e experienciais, contribuindo assim para a construção do conhecimento docente e para o desenvolvimento profissional.

Estes princípios e pressupostos, articulados com os objetivos da ação, resultaram nas seguintes estratégias de ação:

a) Desenvolvimento de processos de comunicação com tecnologias digitais - A ação inicia-se com uma mensagem enviada aos formandos onde se explicita o trabalho autónomo que deverão desenvolver até à primeira sessão síncrona. Na plataforma *Moodle* destinada à ação, é disponibilizado um vídeo em que as formadoras esclarecem as estratégias de formação adotadas, um conjunto de recursos sobre a temática em estudo e uma proposta de trabalho autónomo, para desenvolver a partir da análise e discussão dos recursos. Com esta atividade pretende-se iniciar um processo de comunicação entre formandos, a partir dos recursos disponibilizados, utilizando o fórum para colocar uma questão aos colegas sobre qualquer aspeto que pretendam debater, cujo conteúdo se encontra diretamente relacionado com os processos de comunicação/colaboração com tecnologias digitais.

Numa segunda fase, pretende-se que todos participem ativamente, e que respondam, pelo menos, a duas das questões colocadas pelos colegas. Esta atividade tem o objetivo de estimular os formandos a explorem os recursos disponibilizados e a desenvolverem uma primeira atividade com base no estabelecimento de processos de comunicação abertos, no seio do grupo.

Etapas/Fases	Momentos
Início da ação Disponibilização de informação sobre a organização da formação Disponibilização de recursos necessários à resolução da 1.ª atividade	Início da formação
5 horas de trabalho autónomo com vista ao desenvolvimento de atividades	Formação assíncrona
2 horas de sessão síncrona com as formadoras e Disponibilização de recursos necessários à resolução do 2.º desafio	1.ª sessão síncrona Uma semana depois do início da formação
5 horas de trabalho autónomo com vista ao desenvolvimento de atividades	Formação assíncrona
2 horas de sessão síncrona com as formadoras	2.ª sessão síncrona Duas semanas depois do início da formação
1 hora destinada à reflexão individual	Dois dias depois da 2.ª sessão síncrona

Figura 1 - Esquema geral adotado na formação

b) Construção de conhecimento e promoção da reflexão crítica dos formandos - A primeira sessão síncrona ocorre uma semana depois do início da formação e destina-se a promover a discussão e a reflexão crítica sobre o trabalho autónomo realizado pelos formandos e a sistematizar os conceitos fundamentais associados às práticas colaborativas.

Nesta sessão é ainda apresentada a segunda atividade em que os intervenientes, organizados em pequenos grupos, deverão construir um ambiente facilitador de colaboração e aprendizagem entre pares, utilizando uma ou várias das plataformas *online* sugeridas.

c) Criação de um ambiente favorável à aprendizagem colaborativa - Ainda durante a primeira sessão síncrona, os formandos organizam-se em grupos de trabalho e, em salas simultâneas, discutem temas possíveis para a sua próxima atividade colaborativa, baseados nos seus interesses pessoais/profissionais. É um momento muito importante porque não há qualquer garantia que os formandos já se conheçam e aqui têm a primeira oportunidade de criarem laços que permitam desenvolver confiança para a atividade colaborativa que se segue.

d) Trabalhar colaborativamente com tecnologias digitais - O trabalho autónomo a desenvolver entre as duas sessões síncronas tem o objetivo de colocar os formandos face a uma situação de produção de atividades colaborativas. Pretende-se que este trabalho em grupo seja desenvolvido a partir da diversidade de experiências dos formandos e que o produto resultante possa vir a ser mobilizado na sua prática docente.

A segunda sessão síncrona destina-se à apresentação das atividades colaborativas desenvolvidas pelos grupos de trabalho, sua partilha e discussão em grupo alargado.

f) Análise e reflexão sobre a experiência de formação – No final da segunda sessão síncrona, realiza-se um balanço com os formandos, com a finalidade de identificar os contributos e os desafios decorrentes do trabalho colaborativo com tecnologias digitais para a futura prática docente.

A formação termina com a escrita individual de uma reflexão sobre a formação, onde possa ser destacada a pertinência da formação para a prática letiva dos formandos e com o preenchimento do questionário de avaliação da formação, que seguidamente se explicitará.

V. ANÁLISE DOS DADOS

No final da formação todos os formandos responderam a um inquérito por questionário, com a finalidade de avaliar o desenvolvimento da ação de formação, composto por questões abertas e questões fechadas. O questionário possuía quatro perguntas fechadas que permitiam respostas numa escala de zero a cinco. As perguntas e as respetivas médias, em cada um dos anos letivos, estão representados na figura 2.

	Médias das respostas	
Pergunta	**2020/21**	**2021/22**
Quanto à estrutura da ação	4,2	5
Quanto ao conteúdo	4,6	5
Quanto à interação com a(s) formadora(s)	5	5
Quanto à interação entre formandos	5	4,3

Figura 2 - Média das respostas obtidas às perguntas fechadas do questionário

A análise dos questionários evidenciou que a apreciação dos formandos foi globalmente muito positiva, com todos os domínios em avaliação pontuados entre 4,2 e 5 (classificação máxima). Nas respostas às questões abertas, todos os formandos afirmaram que aconselhariam esta formação a colegas, o que é reforçado nas reflexões: "A formação […] foi, simultânea e harmoniosamente, bastante profícua, aprazível e motivante!" (Formando F, 2020/2021).

Na generalidade, criamos a perceção que a formação foi bem avaliada destacando-se algumas ligeiras diferenças entre os dois anos da sua execução. No ano de 2020/21, a estrutura da formação não foi considerada tão boa quanto no ano seguinte e admitimos que essa diferença possa ser justificada porque, em 2020/21 houve necessidade de adiar a primeira sessão síncrona tendo como consequência a diminuição do tempo destinado à segunda atividade, de caracter eminentemente prático.

Os recursos disponibilizados nas duas edições da formação estão contextualizados no ensino superior, são atuais e constituem-se em torno de um conjunto de vídeos, artigos científicos e sites/blogues com outros recursos. No entanto, em 2020/21, só disponibilizamos uma plataforma *online*, o *Padlet*, para desenvolvimento das atividades colaborativas. Nas perguntas abertas do questionário, os formandos deixaram uma sugestão para que disponibilizássemos várias plataformas para aquele efeito. Essa sugestão foi aceite e, em 2021/22, tiveram a possibilidade de optar por uma das quatro plataformas que sugerimos (*JamBoard*, *Padlet*, *Popplet*, *Wakelet*). A aceitação pelos formandos foi boa, tal como referido por um dos formandos "todo o material disponibilizado, desde artigos, a vídeos, como às próprias plataformas digitais a que podemos recorrer preencheram a formação e irá permitir pesquisas futuras bem como uma maior confiança em utilizar estas metodologias no futuro." (Formando Li, 2021/2022).

Em sentido inverso, a interação entre formandos foi mais bem classificada no primeiro ano, o que nos parece associado às características dos próprios formandos. De facto, o grupo do primeiro ano era ligeiramente maior (5 elementos) e todos completaram com sucesso a formação com um envolvimento muito ativo nas sessões síncronas "Um agradecimento muito especial paras as formadoras, que conseguiram motivar e sensibilizarem-me para este tipo de matérias, contribuindo deste modo, para uma reflexão sobre a forma de como interagimos diariamente, de forma cooperativa, colaborativa ou ambas" (Formando J, 2021/2022). Foi intenção das formadoras construir um ambiente educativo também ele centrado na colaboração, tendo em conta os objetivos da ação de formação, pelas vantagens que a colaboração apresenta e ainda por ser propiciador de futuras utilizações destas estratégias [9]-[14]. O grupo de formandos do segundo ano era constituído por quatro elementos, mas um deles teve uma participação muito irregular, não permitindo uma efetiva colaboração com os colegas.

Apesar destas diferenças entre os dois grupos de formandos, é de salientar que ambos valorizam o papel dos pares para o seu desenvolvimento profissional "Realço ainda o extraordinário ambiente de trabalho, a fluidez relacional e comunicacional coconstruída entre todos os participantes na formação, constante quer nas partilhas em plenário quer nas experiências de efetiva colaboração nas propostas concretizadas em pequeno grupo." (Formando F, 2020/2021), aspeto já referido no quadro teórico por vários autores [9]-[14].

Como já referimos, os formandos são docentes em diferentes escolas da IES e são também oriundos de diferentes áreas disciplinares. Estas diferenças não constituíram qualquer obstáculo à colaboração entre os formandos e verificou-se até que as diferentes culturas organizacionais, científicas e pedagógicas trouxeram contributos muito ricos para o trabalho de grupo.

Uma outra sugestão deixada pelos formandos foi o aumento do tempo destinado à segunda atividade, por exigir trabalho colaborativo e porque a conjugação das disponibilidades dos formandos nem sempre se torna fácil de gerir. Assim, na ação de formação do corrente ano letivo (2022/23), a esta atividade foram atribuídos mais dois dias, tendo sido realizada com a duração de uma semana.

Procuramos que a formação tivesse recursos de qualidade, e que as propostas de atividade fossem desafiantes e promovessem o trabalho entre pares. Os formandos consideram que a formação foi uma experiência enriquecedora: "os desafios propostos nesta formação parecem ter sido criados de maneira a promover […] momentos de reflexão sobre o que poderá ser útil para os alunos, como encontrar novas formas de os motivar para uma aquisição de conhecimentos proativa, centrada nos alunos e em aprendizagens com significado." (Formando La, 2021/2022). Esta é também uma referência às aprendizagens ativas, necessárias para os processos de colaboração [15].

Uma das temáticas tratadas na formação foi a diferença entre trabalho colaborativo e cooperativo. Este tema foi objeto de reflexão de alguns formandos na perspetiva de vir a alterar as suas práticas: "Neste sentido, e de modo a promover o trabalho colaborativo, considero que tenho de repensar o modo como apresento a tarefa do trabalho de grupo dessas UC, assim como a natureza dessa tarefa." (Formando S, 2021/2022). Trata-se de pôr em prática a ideia de que o trabalho colaborativo se estrutura essencialmente como um processo de trabalho articulado, pensado e desenvolvido em conjunto [13]. As reflexões em torno dos contributos da formação para a melhoria de práticas são comuns a muitos dos formandos, com preocupações em termos de estratégias motivadoras para a aprendizagem, tal como evidenciado: "pretendo trabalhar com os alunos de forma colaborativa, porque estou convicta de que essa metodologia de trabalho para além de proporcionar autonomia na busca do conhecimento, aumenta significativamente os níveis motivacionais dos nossos estudantes, que, conseguirão, decerto melhores resultados a nível da sua avaliação final." (Formando E, 2021/2022).

Quanto às competências digitais dos formandos, criámos a perceção que, na generalidade, eram suficientes para utilizar todos os recursos e as plataformas disponibilizadas. No entanto, um dos formandos referiu a necessidade de melhorar essas competências para conseguir usufruir das plataformas de comunicação disponibilizadas, nomeadamente quando desenvolver atividades para os seus alunos as utilizarem.

VI. NOTAS FINAIS

Do ponto de vista global, a formação decorreu de forma muito positiva, quer pelas aprendizagens adquiridas, referidas como significativas pelos formandos, quer pelas dinâmicas colaborativas desenvolvidas pelo grupo, quer ainda pela qualidade do ambiente e das interações desenvolvidas entre estes e as formadoras.

A avaliação feita pelos formandos foi muito positiva, permitindo destacar os pontos fortes da formação eventuais aspetos a melhorar em ações futuras. Do ponto de vista da sua operacionalização futura, pensamos que o número de inscrições deverá ter um mínimo 4 e um máximo de doze, que a segunda sessão síncrona deverá ser realizada uma semana depois da primeira, para permitir mais algum tempo de trabalho colaborativo dos formandos.

O facto do número de formandos ser reduzido nas duas edições da formação – levantamos como hipótese explicativa a possível sobrecarga de trabalho com que os docentes do ES se confrontam nos finais dos semestres letivos —, contribuiu no entanto para a construção de relações de maior proximidade, permitindo às formadoras prestar um feedback mais adequado a cada situação, o que reforça a importância dos processos de comunicação estabelecidos.

Temos consciência que as intencionalidades pedagógicas subjacentes à conceção e ao desenvolvimento da formação foram marcadas pela procura de consistência entre objetivos da formação, os conteúdos e as estratégias pedagógicas desenvolvidas – valorizando sempre os processos de comunicação e de aprendizagem colaborativa [9]-[13]. Por outro lado, a formação procurou integrar os princípios da educação de adultos, partindo das necessidades e desafios sentidos pelos formandos na sua prática profissional, valorizando experiências e saberes adquiridos, promovendo a autonomia e a reflexão crítica, e articulando a teoria e a prática na construção dos saberes profissionais [4], [24], [25]

Destaca-se ainda que a inclusão desta ação de formação no plano de formação da IES é um sinal de reconhecimento e valorização institucional, o qual vem reforçar o interesse e compromisso dos docentes com o seu desenvolvimento profissional. Por outro lado, ao proporcionar situações de partilha de experiências e de saberes entre docentes que pertencem a diferentes escolas e a domínios e áreas científicas distintas, está-se a criar oportunidades para o reforço da comunidade, a autonomia e o conhecimento dos docentes [25].

REFERENCES

[1] M. R. Rodrigues, A. L. O. Pires, E. Ferreira, e M. Baía, Improve Your Teaching. Publication for Academic Teachers, ESE/IPS. Setúbal: IPS, 2020. [Em linha]. Disponível em: https://wspa.pl/wp-content/uploads/2020/12/Improve-Your-Teaching-Publication-for-Academic-Teachers.pdf

[2] A. L. O. Pires, M. do R. Rodrigues, E. Ferreira, J. V. Torres, e M. Baía, «Formação Pedagógica de Professores no Ensino Superior: articulação de competências transversais e TIC em tempo de pandemia», em Livro de Atas 7.o Congresso Nacional de Prática Pedagógicas no Ensino Superior, S. Soares, F. Remião, A. V. Martins, e S. Nunes, Eds., UA Editora - Universidade de Aveiro, 2022.

[3] M. Astudillo, «Modelos blended learning en educación superior.Innovación en la enseñanza», em XVII Encuentro Internacional Virtual Educa Puerto Rico 2016, 2016.

[4] A. Nóvoa e Y. Alvim, Escolas e Professores. Proteger, Transformar, Valorizar. Empresa Gráfica do Estado da Bahia, 2022.

[5] M. Almeida, Desenvolvimento Profissional dos Docentes do Ensino Superior. Contributos para a compreensão do Desenvolvimento Profissional dos docentes que atuam na formação inicial de professores. (Tese de Doutoramento em Ciências da Educação). 2012: Universidade de Lisboa. [Em linha]. Disponível em: https://repositorio.ul.pt/bitstream/10451/8009/1/ulsd064954_td_tese.pdf

[6] J. Marques e P. Pinto, «Formação pedagógica de Professores do Ensino Superior – a experiência da Universidade Nova de Lisboa.», Revista Portuguesa de Pedagogia, vol. 46, n.o 2, pp. 129–149, 2012.

[7] P. Perrenoud, A Prática Reflexiva no Ofício de Professor: Profissionalização e razão pedagógicas. Artmed Editora, 2002.

[8] A. Machado e J. Formosinho, «Equipas Educativas e Comunidades de Aprendizagem», Revista Portuguesa de Investigação Educaciona, vol. 16, n.o 1, pp. 11–31, 2016.

[9] G. Trentin, Technology-enhanced learning and networked collaborative learning,. Woodhead Publishing Limited, 2010.

[10] E. Lai, K. DiCerbo, e P. Foltz, Report Skills for today - What We Know about Teaching and Assessing Collaboration. Pearson, 2017.

[11] A. M. Boavida e J. P. Ponte, «Investigação colaborativa: Potencialidades e problemas», em Reflectir e investigar sobre a prática profissional, Lisboa: APM, 2002, pp. 43–55. [Em linha]. Disponível em: http://www.educ.fc.ul.pt/docentes/jponte/docs-pt%5C02-Boavida-Ponte(GTI).pdf

[12] M. C. Roldão, «Colaborar é preciso – Questões de qualidade e eficácia no trabalho dos professores», Revista Noésis, n.o 71, pp. 30–31, 2007.

[13] A. Trietiak, «Online collaborative learning in higher-education.», AMYTRIETIAK., maio de 2023. https://edspace.american.edu/amytrietiak/2020/05/07/online-collaborative-learning-in-higher-education/

[14] M. Lucas e A. Moreira, DigCompEdu: quadro europeu de competência digital para educadores. Universidade de Aveiro, 2018.

[15] I. Blau e T. Shamir-Inbal, «Digital technologies for promoting "student voice" and co-creating learning experience in an academic course», Instr Sci, vol. 46, n.o 2, pp. 315–336, abr. 2018, doi: 10.1007/s11251-017-9436-y.

[16] D. S. Bajwa, L. F. Lewis, G. Pervan, V. S. Lai, B. E. Munkvold, e G. Schwabe, «Factors in the Global Assimilation of Collaborative Information Technologies: An Exploratory Investigation in Five Regions», Journal of Management Information Systems, vol. 25, n.o 1, pp. 131–166, jul. 2008, doi: 10.2753/MIS0742-1222250106.

[17] J. Amado, N. Crusoé, e P. Vaz-Rebelo, «Quadros Analíticos da Investigação Qualitativa em Educação.», em Manual de Investigação Qualitativa em Educação, Coimbra: Imprensa da Universidade de Coimbra, 2014, pp. 73–104.

[18] T. Gonçalves, «Investigar em Educação: Fundamentos e Dimensões da Investigação Qualitativa.», em Investigar em Educação. Desafios da construção do conhecimento e da formação de investigadores num campo multireferenciado, M. Alves e N. Azevedo, Eds., UIED, 2010.

[19] O. Pombo, «Para um modelo reflexivo de formação de professores», Revista de Educação, vol. 3, n.o 2, pp. 34–37, 1993.

[20] J. P. Ponte e L. Serrazina, «Professores e formadores investigam a sua própria prática: O papel da colaboração», Zetetiké, vol. 11, n.o 20, 2003.

[21] J. P. Ponte, «Investigar a nossa própria prática: uma estratégia de formação e de construção do conhecimento profissional», Revistas de La Universid de Granada, vol. 2, n.o 4, pp. 153–180, 2008, doi: https://doi.org/10.30827/pna.v2i4.6196.

[22] D. Schon, Educando o profissional reflexivo: um novo design para o ensino e aprendizagem. ArtMed Editora, 1998.

[23] W. Carr e S. Kemmis, «Staying Critical», Educational Action Research, 2005, doi: 10.1080/09650790500200296.

[24] A. L. Pires, «Experiencialidade e Complexidade. Contributos para pensar a Formação de Adultos», INTERAÇÕES, n.o 37, pp. 83–99, 2015.

[25] A. Nóvoa. Formação de Professores e trabalho pedagógico. Educa, 2002.

APRENDIZAGEM BASEADA EM JOGOS: UMA ESTRATÉGIA PARA O ENSINO DE CONTEÚDOS PROGRAMÁTICOS EM CONTEXTO DE SALA DE AULA

João Batista
Escola Superior de Educação de Viseu
Instituto Superior Miguel Torga
Coimbra, Portugal
https://orcid.org/0000-0001-7565-7961

***Abstract*— Gamification of educational content has been explored as a strategy to keep students motivated and engaged in the teaching-learning process. This paper seeks to investigate whether the use of game-based learning, in particular the Kahoot! platform, can be a valid strategy in the classroom, preparing students for a theoretical assessment. The study was conducted with 39 students from the Plastic Arts and Multimedia course, from the 1st year and 2nd semester, from the School of Education of Viseu. The results were obtained through a questionnaire and showed that gamification using Kahoot! increased student engagement by incorporating game elements such as points and leaderboards. This approach showed promise for improving students' motivation and helping them achieve their academic goals more effectively. The results indicate that game-based learning can be a valid teaching-learning strategy in the classroom.**

Keywords—gamificação, aprendizagem baseada em jogos, lúdico, ensino-aprendizagem, motivação

I. INTRODUÇÃO

A capacidade de aprendizagem está diretamente relacionada com a motivação "(...) a motivated learner cannot be stopped." [1]. Um dos maiores desafios dos docentes no ensino contemporâneo é conseguir manter a motivação, empenho e concentração dos alunos durante a aula. A falta de motivação pode levar a uma redução dos resultados de aprendizagem [2, 3]. Uma das razões que tem contribuído para a desmotivação dos alunos é a metodologia utilizada durante as aulas onde, muitas vezes, o foco está centrado essencialmente no docente e não nos alunos [4, 5]. Para [4], a dinâmica paradigmática no ensino tradicional, onde os alunos permanecem sentados e concentrados na resolução de tarefas ou atividades repetitivas por longos períodos de tempo, acaba por se tornar extremamente entediante. De ressalvar que a aprendizagem do aluno não depende apenas do fator cognitivo, mas também da sua motivação pessoal [4].

De acordo com diferentes estudos, o interesse dos alunos começa a diminuir significativamente por volta do 18º minuto de aula. Para combater este problema, os docentes devem essencialmente desenvolver conteúdos mais cativantes, divertidos e interativos [6]. Outros estudos, sugerem a necessidade de uma mudança no sistema educativo universitário que, atualmente, está orientado para uma abordagem mais teórica do que um ensino profissional [7]. Existem algumas abordagens que podem tornar as aulas mais dinâmicas e interativas para os alunos, por exemplo, dividindo a turma em grupos mais pequenos, apresentando mais casos práticos onde os alunos possam trabalhar, organizar debates, organizar palestras com convidados, utilizar simulações, recursos audiovisuais e apresentações dinâmicas [8]. A desmotivação generalizada dos alunos para com o sistema de aprendizagem tem trazido nos últimos anos diversas pesquisas sobre gamificação em ambientes de aprendizagem [9, 10, 11, 12, 13] que têm demonstrado ser promissoras, com resultados maioritariamente positivos [14, 15, 16].

Tendo em consideração a desmotivação e dificuldade em reter informação de forma generalizada dos estudantes, este artigo investiga a utilização de uma aprendizagem baseada em jogos como estratégia válida de ensino-aprendizagem em sala de aula capaz de preparar os alunos para uma avaliação teórica. Os próximos capítulos do artigo estão organizados da seguinte forma: a secção dois define e distingue conceitos de gamificação e aprendizagem baseada em jogos. A secção três explica as metodologias da investigação que foram utilizadas para o estudo. Na secção quatro, apresentam-se os resultados obtidos e, por fim, a secção cinco as observações/apreciações finais.

II. GAMIFICAÇÃO E APRENDIZAGEM BASEADA EM JOGOS

A gamificação é uma apropriação de elementos de design, mecânicas e pensamento de jogo em contextos que não estão relacionadas com jogos com o objetivo de motivar os participantes, envolvendo-os numa dinâmica que apoia o desempenho e participação em diferentes atividades e comportamentos [17, 18, 19, 20, 21, 22]. Os autores [23] descrevem a gamificação como um processo de melhoria de serviços através da inclusão de elementos motivacionais com intuito de desencadear experiências semelhantes a jogos. No entanto, há uma ideia equivoca que refere que para gamificar, basta adicionar pontuação ou distintivos a uma determinada atividade que não tenha um contexto de jogo, esse elemento, apesar de ser utilizado, acaba por ser menos emocionante. As pessoas não jogam um jogo apenas por pontos, jogam para melhorar as habilidades, para superar desafios e socializar com outros jogadores. As boas experiências que envolvam gamificação, incluem mais do que pontos e/ou distintivos – devem conter narrativas, desafios e feedback contínuo, assim como um alto nível de interatividade. [24].

O conceito de gamificação tem vindo a ganhar popularidade, quer num registo académico: o número de artigos publicados sobre gamificação está a crescer exponencialmente, sugerindo que está a tornar-se num tema mais popular para a investigação académica [23], mas também no meio industrial [16, 20]. No entanto é em contextos educacionais que a gamificação tem recebido maior atenção [25, 26].

A massificação das novas tecnologias exigiu uma adaptação ao sistema educativo na expectativa de conseguir aumentar a motivação e o empenho dos alunos [27, 28] que, tem dado origem a novas formas de interação entre professores e alunos [29]. Estratégias que englobem a gamificação utilizando as novas tecnologias no ambiente de sala de aula, incitam a interatividade e participação em grupo, capaz de melhorar o processo de ensino-aprendizagem [30]. Quando bem implementada os alunos experienciam uma atividade lúdica que melhora espontaneamente a sua aprendizagem, podendo potenciar o seu desempenho académico [31].

Com diferentes formas de incorporar interações lúdicas em contextos educacionais, surgiram diferentes terminologias: gamificação, jogos sérios ou aprendizagem baseada em jogos [26, 32, 33]. Para este estudo é relevante destacar que a gamificação e jogos, mesmo que estejam ambos inseridos num registo educativo, não são a mesma coisa. A aprendizagem baseada em jogos utiliza um jogo real, com início, jogabilidade e final definitivos, especificamente criados para transmitir conhecimentos e/ou habilidades. Os participantes sabem que estão envolvidos numa atividade de jogo. A gamificação, por outro lado, utiliza apenas alguns elementos que constituem um jogo e aplica-as num contexto que não está relacionada com jogos, para além disso, os participantes não têm um início ou fim concreto, participam apenas em atividades que incluem peças de vídeo ou jogos para dispositivos móveis, como ganhar pontos, superar desafios ou receber distintivos pela realização de determinadas tarefas [24].

A aprendizagem baseada em jogos (*game based learning*) está a ser utilizada para incentivar os alunos a participar na aprendizagem enquanto jogam, tornando o processo mais estimulante ao adicionar diversão. Isso tem criado um efeito positivo no desenvolvimento cognitivo [34].

Para desenvolver uma aprendizagem baseada em jogos, existem diferentes plataformas que permitem gamificar conteúdos educacionais, tais como: Socrative, Quizizz e iSpring Learn LMS, com o objetivo de melhorar o desempenho e o envolvimento dos alunos [35]. Entre os vários jogos que envolvem um contexto educacional, existe a plataforma Kahoot!, criada pelo professor Alf Inge Wang. Uma plataforma parcialmente gratuita que permite os alunos participarem ativamente no processo de ensino-aprendizagem através de questionários previamente desenvolvidos [36].

Para utilizar o Kahoot!, os docentes devem criar uma conta de utilizador na plataforma web. A partir desse momento, têm a possibilidade de elaborar questionários na plataforma online que, podem incluir questões de verdadeiro ou falso, ou quatro alternativas de resposta. O programa permite adicionar diferentes conteúdos multimédia: vídeos, fotos e música com o intuito de realçar a experiência de jogo, oferecendo um ambiente dinâmico e motivador. Para participar, os alunos não precisam de criar uma conta na plataforma Kahoot!,basta acederem ao website ou aplicativo através de um dispositivo móvel, como smartphone, tablet ou computador, desde que, tenha acesso à internet. Para entrar no jogo, é utilizado um código próprio que a plataforma gera automaticamente para o criador do jogo que, posteriormente, distribui aos alunos. Durante a experiência de jogo, os alunos selecionam a opção de resposta que consideram correta, sendo motivados pelo tempo limitado e pela consciência de que o sucesso e a rapidez de resposta são recompensados [37]. No final do jogo, a plataforma apresenta um pódio, onde surgem os três alunos vencedores da experiência lúdica [38].

A gamificação de conteúdos lecionado em aulas a partir de uma aprendizagem baseada em jogos como o Kahoot!,pode aumentar o envolvimento dos alunos ao incorporar mecânicas de jogo comuns nos videojogos como: pontos, tabelas de classificação e distintivos que, demonstraram atrair e cativar milhões de utilizadores [39, 40, 41, 42, 43, 44]. Ao integrar as mecânicas de jogo que os criadores de videojogos utilizam para aumentar e manter o envolvimento dos jogadores, a gamificação em ferramentas académicas e pedagógicas, tem o potencial de elevar e manter esse mesmo envolvimento, resultando um aumento da motivação dos alunos e permitindo- lhes atingir os seus objetivos e conquistas académicas de forma mais eficaz. [45, 46, 47].

III. Metodologia

Com este artigo pretende-se avançar com a resposta à seguinte questão: **Pode uma aprendizagem baseada em jogos ser uma estratégia de ensino-aprendizagem válida em contexto de sala de aula, auxiliando os alunos na preparação para uma prova de avaliação teórica?** Utilizando especificamente dados recolhidos por inquérito por questionário, respondido por um grupo particular de alunos, nomeadamente, 39 estudantes do Ensino Superior do Curso de Artes Plásticas e Multimédia, do 1º ano e 2º semestre da Escola Superior de Educação de Viseu que frequentam a Unidade Curricular “Interação Utilizador-Computador”.

O presente estudo privilegiou uma abordagem quantitativa que decorreu durante o mês de maio de 2023. Os dados aqui reportados foram coletados através da técnica de recolha de dados inquérito por questionário, dado que é uma técnica que se situa no âmbito do método de medida ou de análise extensiva, permite o estudo de populações colocadas em situações sociais concretas, possibilitando a generalização dos resultados alcançados [48]. Podemos, portanto, definir inquérito por questionário como uma “técnica de investigação composta por um conjunto de questões que são submetidas a pessoas com o propósito de obter informações (…)” [49]. Este inquérito foi respondido em contexto de sala de aula por 39 alunos do Ensino Superior do Curso de Artes Plásticas e Multimédia da Escola Superior de Educação de Viseu. Neste estudo em particular, o inquérito aplicado pretendeu obter informações sobre se a gamificação dos conteúdos programáticos da unidade curricular “Interação Utilizador- Computador” apresentada aos alunos a partir de uma aprendizagem baseada em jogos, pode ser uma estratégia de ensino-aprendizagem válida em contexto de sala de aula, preparando os alunos para uma prova de avaliação teórica. No seguimento, o inquérito aplicado foi constituído maioritariamente por questões fechadas, o que veio facilitar a análise de dados através do programa IBM® SPSS Statistics.

O inquérito por questionário divide-se em quatro partes. A primeira permitiu recolher dados demográficos do público- alvo; a segunda teve como objetivo averiguar se o jogo permitiu consolidar conhecimentos sobre a matéria lecionada na unidade curricular; a terceira procurou perceber se os inquiridos sentiram motivação, competitividade e, se o jogo permitiu estimular o raciocínio e reter os conteúdos da unidade curricular; e, por último na quarta parte foi dada a opção aos inquiridos de deixarem observações a partir de uma resposta aberta, sobre a experiência de jogo em sala de aula.

IV. Resultados

O presente estudo contou com uma amostra de 39 alunos com idades compreendidas entre os 18 e os 25 anos de idade. Após a recolha de dados e tratamento dos dados estatísticos, foi possível constatar que, relativamente à frequência com que os alunos utilizam jogos fora do contexto educacional, comparativamente à familiaridade com tecnologias, 41,7% (n=16) dos alunos que utilizam diariamente jogos fora do contexto educativo está muito familiarizado ou familiarizado com as novas tecnologias. Isto é, dos dados obtidos, os alunos que utilizam jogos no seu quotidiano são aqueles que estão mais confortáveis com a utilização das novas tecnologias. A maioria dos alunos inquiridos 58,4% (n=22), considera que através da gamificação dos conteúdos apresentados numa aprendizagem baseada em jogos é possível consolidar conhecimento teórico, em particular, na Unidade Curricular “Interação Utilizador- Computador”. Contudo, não se pode deixar de referir que, 33,3% (n=13) se manteve na dúvida em relação à consolidação de conhecimento. Percebeu-se igualmente que 53,8% (n=21) dos alunos ficaram satisfeitos ou muito satisfeitos em ter aprendizagem baseada em jogos para preparação de um teste teórico e 76,9% (n=30) concorda ou, concorda totalmente, que este tipo de jogo deveria ser aplicado a outras unidades curriculares como estratégia de ensino válida para preparação de uma prova de avaliação. Também 69,2% (n=27) concorda ou concorda totalmente que este tipo de jogo torna o processo de aprendizagem mais envolvente e motivador.

No entanto, quando os inquiridos foram questionados sobre a possibilidade de um docente lecionar a matéria apenas a partir de jogos, sem que fosse complementada com outras estratégias de ensino-aprendizagem tradicionais durante o semestre, como aulas expositivas ou atividades em sala de aula, apenas 30,8% (n=12) acreditam ser viável, 35,9% (n=14) não acham viável e 33,3 (n=13) não têm a certeza.

Por fim, no final do inquérito, os alunos inquiridos tinham a opção de deixar breves comentários / reflexões sobre a experiência lúdica. Dos 39 alunos, 41% (n=16) decidiu comentar, sendo que destes 50% (n=8), demonstram que existe um elevado interesse em utilizar aprendizagem baseada em jogos em outras unidades curriculares que envolvam principalmente conteúdos teóricos, por considerarem uma forma lúdica e participativa de consolidar o conhecimento. No entanto, os inquiridos consideram que seria benéfico existirem mais aprendizagem baseada em jogos durante o semestre, em vez de existir apenas um jogo de preparação para o teste teórico.

V. Conclusão

Após o tratamento e análise dos resultados, observou-se que a maioria dos alunos que experienciou a gamificação dos conteúdos apresentados em sala de aula a partir de uma aprendizagem baseada em jogos desenvolvido no Kahoot!, reconheceu-a como uma maneira de consolidar o conhecimento teórico na Unidade Curricular "Interação Utilizador- Computador". Para além disso, sentiram-se satisfeitos por estar a jogar um jogo como forma de preparação para um teste teórico e destacaram que torna o processo de aprendizagem mais envolvente e motivador, o que sugere benefícios adicionais, além da simples consolidação do conhecimento. A maioria também concordou que essa abordagem poderia ser aplicada a outras unidades curriculares como uma estratégia de ensino válida para a preparação de provas de avaliação, indicando um interesse em utilizar mais jogos relacionados com a matéria de diferentes unidades curriculares.

Uma percentagem significativa dos alunos que utiliza jogos fora do contexto educacional, está familiarizada com as novas tecnologias, este facto sugere que a utilização de jogos como ferramenta de aprendizagem pode ser eficaz, especialmente para alunos que já têm afinidade com tecnologia e jogos. No geral, depreende-se que a aprendizagem baseada em jogos desenvolvidos em plataformas como o Kahoot! podem ser uma abordagem de ensino-aprendizagem promissoras para preparar os alunos para avaliações teóricas.

Dos resultados conseguimos ainda aferir que, quando questionados sobre a possibilidade de um docente lecionar a matéria apenas por meio de jogos, sem complementar com outras estratégias de ensino, uma proporção significativa de alunos expressou dúvidas ou não considerou viável essa abordagem. Os comentários e reflexões dos alunos destacaram um interesse em utilizar jogos relacionados com a matéria em diferentes unidades curriculares como forma lúdica e participativa de consolidar o conhecimento. Contudo, os alunos também mencionaram que seria benéfico distribuir vários jogos ao longo do semestre, em vez de se concentrar apenas um jogo para a preparação do teste teórico.

De referir que, os dados aqui apresentados estão limitados a uma amostra de 39 alunos do ensino superior de uma unidade curricular específica o que, impossibilita uma generalização dos resultados para toda a população de estudantes do ensino superior. Por sua vez, torna-se igualmente pertinente referir que os resultados obtidos neste estudo podem diferir como estratégia de ensino-aprendizagem mediante a sua aplicação em outros cursos e unidades curriculares do ensino superior.

Os resultados preliminares deste estudo sugiram que a gamificação de conteúdos programáticos a partir de uma aprendizagem baseada em jogos possa ser uma estratégia válida de ensino-aprendizagem em sala de aula. Seria igualmente pertinente, realizar pesquisas adicionais com amostras maiores e variadas para obter resultados mais completos e conclusivos. Pesquisas futuras e mais alargadas podem ainda explorar outras questões relacionadas com a docência como, por exemplo, se os docentes estão preparados para assimilar, criar e aplicar a gamificação de conteúdos a partir de aprendizagem baseada em jogos como forma de ensino-aprendizagem; se os docentes já utilizam este tipo de estratégia, quantos são e qual a sua experiência com a sua aplicação, bem como se são conhecedores/utilizadores de plataformas que permitem a criação de aprendizagem baseada em jogos.

References

[1] Prensky, M. (2003). Digital game-based learning. Computers in Entertainment (CIE), 1(1), 21-21.

[2] O. L. Liu, B. Bridgeman, and R. M. Adler, "Measuring Learning Outcomes in Higher Education," Educational Researcher, vol. 41, no. 9. American Educational Research Association (AERA), pp. 352–362, Dec. 2012. doi: 10.3102/0013189x12459679.

[3] F. F. Paiva, D. M. Lemos Barbato, M. L. M. Fernandes Paiva, H. A. João, and S. R. Muniz, "Orientações motivacionais de alunos do ensino médio para física: considerações psicométricas," Revista Brasileira de Ensino de Física, vol. 40, no. 3. FapUNIFESP (SciELO), Mar. 26, 2018. doi: 10.1590/1806-9126-rbef-2017-0343.

[4] C. Schroeder, "A importância da física nas quatro primeiras séries do ensino fundamental," Revista Brasileira de Ensino de Física, vol. 29, no. 1. FapUNIFESP (SciELO), pp. 89–94, 2007. doi: 10.1590/s1806-11172007000100015.

[5] M. F. Parisoto and T. R. Hilger, "Investigação da aprendizagem de conceitos de óptica utilizando ilusões para turmas de pré-vestibular," Revista Brasileira de Ensino de Ciência e Tecnologia, vol. 9, no. 1. Universidade Tecnologica Federal do Parana (UTFPR), Aug. 29, 2016. doi: 10.3895/rbect.v9n1.2109.

[6] D. M. Bunce, E. A. Flens, and K. Y. Neiles, "How Long Can Students Pay Attention in Class? A Study of Student Attention Decline Using Clickers," Journal of Chemical Education, vol. 87, no. 12. American Chemical Society (ACS), pp. 1438–1443, Oct. 22, 2010. doi: 10.1021/ed100409p.

[7] J. M. Barcelo, "Medical laboratory science and nursing students' perception of the academic learning environment at a Philippine university using the Dundee Ready Education Environment Measure," Journal of Educational Evaluation for Health Professions, vol. 13. Korea Health Personnel Licensing Examination Institute, p. 33, Sep. 22, 2016. doi: 10.3352/jeehp.2016.13.33.

[8] Y. Steinert. Snell Linda S., "Interactive lecturing: strategies for increasing participation in large group presentations," Medical Teacher, vol. 21, no. 1. Informa UK Limited, pp. 37–42, Jan. 1999. doi: 10.1080/01421599980011.

[9] van Gaalen, A. E. J., Brouwer, J., Schönrock-Adema, J., Bouwkamp-Timmer, T., Jaarsma, A. D. C., & Georgiadis, J. R. (2020). Gamification of health professions education: a systematic review. In Advances in Health Sciences Education (Vol. 26, Issue 2, pp. 683–711). Springer Science and Business Media LLC. https://doi.org/10.1007/s10459-020-10000-3

[10] Nieto-Escamez, F. A., & Roldán-Tapia, M. D. (2021). Gamification as Online Teaching Strategy During COVID-19: A Mini-Review. In Frontiers in Psychology (Vol. 12). Frontiers Media SA. https://doi.org/10.3389/fpsyg.2021.648552.

[11] J. B. da Silva, G. L. Sales, and J. B. de Castro, "Gamificação como estratégia de aprendizagem ativa no ensino de Física," Revista Brasileira de Ensino de Física, vol. 41, no. 4. FapUNIFESP (SciELO), 2019. doi: 10.1590/1806-9126-rbef-2018-0309.

[12] J. B. da S. da Silva, M. H. Andrade, R. R. de Oliveira, G. L. Sales, and F. R. V. Alves, "Tecnologias digitais e metodologias ativas na escola: o contributo do Kahoot para gamificar a sala de aula," Revista Thema, vol. 15, no. 2. Instituto Federal de Educacao, Ciencia e Tecnologia Sul-Rio-Grandense, pp. 780–791, May 20, 2018. doi: 10.15536/thema.15.2018.780-791.838.

[13] O. E. Bjælde, M. K. Pedersen, and J. Sherson, "Gamification of Quantum Mechanics Teaching." arXiv, 2015. doi: 10.48550/ARXIV.1506.08128.

[14] I. Caponetto, J. Earp, and M. Ott, 'Gamification and Education: a Literature Review', Proceedings of the 8th European Conference on Games-Based Learning - ECGBL 2014, vol. 1, pp. 50–57, 10 2014.

[15] B. Osatuyi, T. Osatuyi, and R. de la Rosa, "Systematic Review of Gamification Research in IS Education: A Multi-method Approach," Communications of the Association for Information Systems, vol. 42. Association for Information Systems, 2018. doi: 10.17705/1cais.04205.

[16] J. Majuri, J. Koivisto, and J. Hamari, 'Gamification of Education and Learning: A Review of Empirical Literature', 05 2018.

[17] S. Deterding, R. Khaled, L. Nacke, and D. Dixon, 'Gamification: Toward a definition', C. Gamification Workshop Proceedings, Vancouver, BC, 2011, pp. 12–15.

[18] C. E. Holbrey, "Kahoot! Using a game-based approach to blended learning to support effective learning environments and student engagement in traditional lecture theatres," Technology, Pedagogy and Education, vol. 29, no. 2. Informa UK Limited, pp. 191–202, Mar. 12, 2020. doi: 10.1080/1475939x.2020.1737568.

[19] S. Deterding, M. Sicart, L. Nacke, K. O'Hara, and D. Dixon, "Gamification. using game-design elements in non-gaming contexts," CHI '11 Extended Abstracts on Human Factors in Computing Systems. ACM, May 07, 2011. doi: 10.1145/1979742.1979575.

[20] R. Al-Azawi, F. Al-Faliti, and M. Al-Blushi, "Educational Gamification Vs. Game Based Learning: Comparative Study," International Journal of Innovation, Management and Technology, vol. 7, no. 4, pp. 131–136, 2016, doi: https://doi.org/10.18178/ijimt.2016.7.4.659.

[21] K. Huotari and J. Hamari, "A definition for gamification: anchoring gamification in the service marketing literature," Electronic Markets, vol. 27, no. 1, pp. 21–31, Jan. 2016, doi: https://doi.org/10.1007/s12525-015-0212-z

[22] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness," Proceedings of the 15th International Academic MindTrek Conference on Envisioning Future Media Environments - MindTrek '11, pp. 9–15, Sep. 2011.

[23] J. Hamari, J. Koivisto, and H. Sarsa, "Does Gamification Work? -- a Literature Review of Empirical Studies on Gamification," 2014 47th Hawaii International Conference on System Sciences, pp. 3025–3034, Jan. 2014, doi: https://doi.org/10.1109/hicss.2014.377

[24] K. Kapp, "What is Gamification", *The gamification of learning and instruction: Game-based methods and strategies for training and education*, pp. 1–23, 2012.

[25] J. Koivisto and J. Hamari, "The Rise of Motivational Information Systems: A Review of Gamification Research," SSRN Electronic Journal, vol. 45, pp. 191–210, 2017, doi: https://doi.org/10.2139/ssrn.3226221

[26] K. Seaborn and D. I. Fels, “Gamification in theory and action: A survey,” International Journal of Human-Computer Studies, vol. 74, no. 1, pp. 14– 31, Feb. 2015, doi: https://doi.org/10.1016/j.ijhcs.2014.09.006.

[27] M. M. Hoffmann and A. Y. Ramirez, “Students’ Attitudes toward Teacher Use of Technology in Classrooms,” 21st Century Learning & Multicultural Education, vol. 25, no. (2), pp. 51–56, 2018.

[28] H. H. Ã–zer, S. Kanbul, and F. Ozdamli, “Effects of the Gamification Supported Flipped Classroom Model on the Attitudes and Opinions Regarding Game-Coding Education,” International Journal of Emerging Technologies in Learning (iJET), vol. 13, no. 01. International Association of Online Engineering (IAOE), p. 109, Jan. 22, 2018. doi: 10.3991/ijet.v13i01.7634.

[29] D. J. Gould, M. A. Terrell, and J. Fleming, “A usability study of users’ perceptions toward a multimedia computer-assisted learning tool for neuroanatomy,” Anatomical Sciences Education, vol. 1, no. 4. Wiley, pp. 175–183, Jul. 2008. doi: 10.1002/ase.36.

[30] M. Prensky, "Don’t Bother Me Mom, I’m Learning!": How Computer and Video Games Are Preparing Your Kids for Twenty-First Century Success and How You Can Help! Paragon House: St. Paul, MN, USA, 2006; p. 254.

[31] I. Bouchrika, N. Harrati, V. Wanick, and G. Wills, “Exploring the impact of gamification on student engagement and involvement with e-learning systems,” Interactive Learning Environments, vol. 29, no. 8. Informa UK Limited, pp. 1244–1257, Jun. 07, 2019. doi: 10.1080/10494820.2019.1623267.

[32] R. N. Landers, “Developing a Theory of Gamified Learning,” Simulation & Gaming, vol. 45, no. 6, pp. 752–768, Dec. 2014, doi: https://doi.org/10.1177/1046878114563660.

[33] S. P. Walz and S. Deterding, “The Ambiguity of Games: Histories and Discourses of a Gameful World,” Social Science Research Network, p. 688, Jul. 2014.

[34] W.-C. Lin, J.-Y. Ho, C.-H. Lai, and B.-S. Jong, “Mobile game-based learning to inspire students learning motivation,” 2014 International Conference on Information Science, Electronics and Electrical Engineering, Apr. 2014, doi: https://doi.org/10.1109/infoseee.2014.6947779.

[35] Z. Zainuddin, M. Shujahat, H. Haruna, and S. K. W. Chu, “The role of gamified e-quizzes on student learning and engagement: An interactive gamification solution for a formative assessment system,” Computers & Education, vol. 145. Elsevier BV, p. 103729, Feb. 2020. doi: 10.1016/j.compedu.2019.103729.

[36] E. P. Holguín, P. G. Madera, B. H. R. Valdepeñas, and M. L. del Hierro Casado, ‘Kahoot en docencia: una alternativa practica a los clickers’, XI Jorn. Int. Innovación Univ. Educ. Para Transform. 2014, 322–329.

[37] S. G. Bryant, J. M. Correll, and B. M. Clarke, “Fun With Pharmacology: Winning Students Over With Kahoot! Game-Based Learning,” Journal of Nursing Education, vol. 57, no. 5. SLACK, Inc., pp. 320–320, May 2018. doi: 10.3928/01484834-20180420-15.

[38] A. Corell, L. M. Regueras, E. Verdú, M. J. Verdú, and J. P. de Castro, “Effects of competitive learning tools on medical students: A case study,” PLOS ONE, vol. 13, no. 3. Public Library of Science (PLoS), p. e0194096, Mar. 08, 2018. doi: 10.1371/journal.pone.0194096.

[39] K. E. Cameron and L. A. Bizo, “Use of the game-based learning platform KAHOOT! to facilitate learner engagement in Animal Science students,” Research in Learning Technology, vol. 27, no. 0. Association for Learning Technology, May 15, 2019. doi: 10.25304/rlt.v27.2225.

[40] M. A.-A. Ismail and J. A.-M. Mohammad, “Kahoot: A Promising Tool for Formative Assessment in Medical Education,” Education in Medicine Journal, vol. 9, no. 2. Penerbit Universiti Sains Malaysia, pp. 19–26, 2017. doi: 10.21315/eimj2017.9.2.2.

[41] S. Nicholson, “A RECIPE for Meaningful Gamification,” Gamification in Education and Business. Springer International Publishing, pp. 1–20, Oct. 17, 2014. doi: 10.1007/978-3-319-10208-5_1.

[42] A. K. Przybylski, C. S. Rigby, and R. M. Ryan, “A Motivational Model of Video Game Engagement,” Review of General Psychology, vol. 14, no. 2. SAGE Publications, pp. 154–166, Jun. 2010. doi: 10.1037/a0019440.

[43] N. Whitton, Ed., “Motivation and computer game based learning.,” Proceedings of the Australian Society for Computers in Learning in Tertiary Education, pp. 2–5, 2007

[44] N. Whitton, “Game Engagement Theory and Adult Learning,” Simulation & Gaming, vol. 42, no. 5. SAGE Publications, pp. 596–609, Aug. 10, 2010. doi: 10.1177/1046878110378587.

[45] G. Goehle, “Gamification and Web-based Homework,” PRIMUS, vol. 23, no. 3. Informa UK Limited, pp. 234–246, Mar. 2013. doi: 10.1080/10511970.2012.736451.

[46] C. Muntean, ‘Raising engagement in e-learning through gamification’, Proc. 6th International Conference on Virtual Learning ICVL, 01 pp.323- 329, 2011.

[47] F. F.-H. Nah, Q. Zeng, V. R. Telaprolu, A. P. Ayyappa, and B. Eschenbrenner, “Gamification of Education: A Review of Literature,” Lecture Notes in Computer Science. Springer International Publishing, pp. 401–409, 2014. doi: 10.1007/978-3-319-07293-7_39.

[48] M. I. Dias, O inquérito por questionário: problemas teóricos e metodológicos gerais. Porto: 1994.

[49] A. C. Gil, Métodos e técnicas de pesquisa social, 6º ed., Editora Atlas SA., 2008.

GEOGEBRA APPLET TO LEARN PROGRAMMING AND DEBUGGING IN MATHEMATICS LESSONS

1st Wahid Yunianto
STEM Education Department
Johannes Kepler University Linz
Linz, Austria
yunianto.wah@gmail.com

2nd Guillermo Bautista Jr
STEM Education Department
Johannes Kepler University Linz
Linz, Austria
gpbautista1@up.edu.ph

3rd Rully Charitas Indra Prahmana
Mathematics Education Department
Ahmad Dahlan University, Indonesia
rully.indra@mpmat.uad.ac.id

4th Zsolt Lavicza
STEM Education Department
Johannes Kepler University Linz
Linz, Austria
zsolt.lavicza@jku.at

***Abstract*—This study presents the development of integrated computational thinking in mathematics lessons. The lessons were intended to support students' computational thinking while learning mathematics. To do so, we used the educational design research (EDR) methodology to develop the lessons. We collaborated with mathematics teachers and practitioners to improve the lessons. We also piloted the lessons for a few junior high school students in Indonesia. We collected data from online discussions with teachers and practitioners, GeoGebra files, and screen video recordings. We found that collaboration with teachers and practitioners helped us to refine the lessons. The pilot study showed the engagement of students in programming and debugging. Mostly students could solve the final task to create an inscribed polygon in a circle.**

Keywords—computational thinking, programming, debugging, mathematics, inscribed polygon, circle

I. INTRODUCTION

Computational thinking (CT) has gained great attention from countries and researchers. Computational thinking is regarded as an essential skill like reading, writing, and arithmetic that everybody should possess [1]. In education, some countries have included CT in their curriculum [2] and prepared their teachers with CT knowledge and skills [3]. CT can be taught not only in computer science (CS) courses [1]. It can be integrated into other school subjects such as mathematics, science, language, arts, etc.

There are two ways to deliver CT namely unplugged and plugged. The unplugged coined in 1998 by Bell and colleagues [4], means that CT activities are conducted without computers or information processing agents. Meanwhile, the plugged CT uses computers and similar devices for students to learn. Students can experience both activities and benefit from them. Our study developed CT integration in mathematics lessons in the plugged mode. We used GeoGebra, a mathematics software, to engage students to do programming and debugging. GeoGebra is an accessible software for mathematics teachers so it will be easier for them to use it.

Through the educational design research methodology (EDR) by [5], we collaborated with mathematics teachers, and practitioners to develop mathematics+CT lessons. The lessons evolved through the discussion and revision from draft 1 to draft 2. The draft 2 was implemented for a few junior high school students. From this pilot trial, we also improved the lessons resulting in draft 3.

This paper will present how the collaboration with teachers and a practitioner has helped us to improve the lessons and how the revised lessons have been piloted to a few students. Through EDR, we refined our lessons, especially on the display, features, information, and additional tasks. From the students' work, we witnessed most students could accomplish the final task and yet they struggled with the debugging task containing too many errors to be fixed.

II. BACKGROUND WORK

A. Computational Thinking

The term computational thinking (CT) was first introduced by Seymour Papert in 1980's. Papert [6] described CT as a way of learning through interaction with computers. He and his colleagues develop LOGO geometry for students to do programming. Later, in 2006, Wing [1] rejuvenated CT and it became popular since then. She argued that CT is a foundational skill like reading, writing, and arithmetic. Wing defined CT as a problem-solving skill that either humans or processing information agents, or a combination can do to get a solution [1]. On another occasion and year, Wing defined CT differently as though processes to think like a computer scientist when solving problems [7]. Throughout the years Wing defined CT differently and CT has not yet had a universal definition. Studies in integrating CT in Mathematics benefitted students [8], [9], [3].

B. GeoGebra and Computational Thinking

GeoGebra is a dynamic geometric software commonly used to teach geometry and algebra. Mathematics teachers can use this software freely either offline or online. The use of GeoGebra in mathematics education has benefitted students in learning mathematics [10][11][12]. Therefore, our study used this software to support students learning mathematics and computational thinking.

Studies of using GeoGebra in integrating CT in mathematics are still few [8], [13]. van Borkulo and her colleagues conducted research using GeoGebra and found that their lessons supported students' algorithmic thinking. As research in using GeoGebra to integrate CT in mathematics lessons is limited, we tried to contribute to this field by developing GeoGebra-based mathematics+CT lessons.

III. Framework

There are some frameworks for integrating CT in education. We studied the frameworks and selected the one that is more operational and could help us develop the mathematics+CT lessons.

As CT gained great attention, especially in education, some researchers developed the CT framework so that it is more operationalized. There are some frameworks to integrate CT in education such as [14], [15] and also [16]. They proposed quite distinct CT concepts, practices, and perspectives. This paper referred to the last one, to develop the mathematics+CT lessons. The Shute [16] and colleagues' framework improved the previous two due to their limitations on the subject area and grade level. There are six facets, namely, decomposition, abstraction, algorithm, debugging, iteration, and generalization. Due to the limitations of the pages, we will describe the programming and debugging facets of our study.

A. Programming and Debugging

Programming refers to designing logical and ordered instructions for solving problems to get solutions [16]. The instructions can be executed by human(s) or computer(s). Programming has smaller sub-facets, algorithm design, parallelism, efficiency, and automation. Briefly, the algorithm is to develop the steps or instructions. The parallelism is to do different tasks at the same time. The efficiency is to make fewer steps. The automation means automating the execution of similar problems. The GeoGebra applet in our study integrated these sub-facets. It can be used to input commands, to define variables, to run different commands at the same time, and to let students make different steps and lastly to make different objects with the previously designed program. Students in our study learn how to input commands to construct points, polygons, internal angles, variables, and circles. For parallelism, GeoGebra allows making simultaneous objects such as ‘Execute[{"A=(1,2)","B=(3,4)","C=(5,6)"}]’ to plot points A, B, and C in one shoot.

Debugging is another facet that requires students to detect and identify errors or bugs and then fix them so that the object(s) can be constructed successfully [16]. We intentionally designed tasks with a fictional name; Andi who wrote commands to construct a polygon and or a circle. The commands' errors included typological errors, missing letter(s), case sensitivity, and order. For instance, Andi wrote A=(1:2) instead of A=(1,2), this error belongs to case sensitivity. Andi used colon (:) instead of comma (,) and GeoGebra will still execute it but does not produce a point but a slider (number).

Regarding the errors, students will get a notification if the command is incorrect, and this is called interruption. There are two interruptions namely, immediate-style interruption and negotiated-style interruption [17]. The first one refers to the instant notification when the users made a mistake, and it can be a pop-up window. The latter is when the users will not know if the errors are there until they found them by themselves. For instance, A=(1:2) will be a negotiated-style interruption as students will not get any error notification until A is used to make a point in a circle or in a polygon.

B. Constructionist Theory

Our study is based on the constructionist theory by Papert [6]. He introduced computational thinking in education, especially in mathematics education. His idea of computational thinking is about interaction with a learning environment in the computer to learn or access knowledge. Papert proposed a key to learning: activity engagement, ownership of ideas & learning style, and exposure. The GeoGebra-based mathematics+CT lessons were designed for students to construct objects (engagement), arrange the commands based on their ideas (ownership of ideas) and work on similar tasks or sequences (exposure).

How computer scientists solved difficult problems using LISP programming inspired Papert to develop a similar tool for young learners to do mathematics with [18]. Papert and his colleagues developed LOGO, a similar tool mentioned earlier that later evolved into Turtle Geometry. Young learners programmed this tool to construct geometrical figures. Our study incorporated GeoGebra to develop an environment (applet) where students can input their algorithms to construct objects to learn mathematical concepts or solve problems. GeoGebra can be set up into a programming tool by its input box feature and scripts or commands. We intentionally hide the drawing or construction tools by displaying only the cursor/pointer or move tool.

IV. Methodology

To help us understand how to integrate CT into mathematics education, we used educational design research (EDR) by [5]. The nature of this methodology allows us to do iteration to improve our lessons and to understand how it works and why it works.

A. Educational Design Research

The EDR is suitable for our study as it helps to develop the mathematics lessons integrating CT. EDR has 3 stages in the cycle namely, 1) exploration and analysis, 2) design and construction, and 3) evaluation and reflection [5, p. 83].

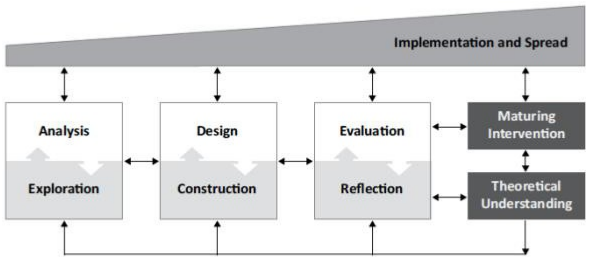


Fig. 1. Generic model for conducting design research in education

In stage 1, the first author analyzed the curriculum in Indonesia. It is found that CT is learned in computer science (CS) subjects and as CS is new in the curriculum, CT is not yet available in other subjects. In the curriculum document, CT in Indonesia refers to problem-solving and mainly the CT activities are unplugged. Interviews have been done with the expert and practitioners who developed the CS curriculum and trained teachers. We did not find yet resources to learn mathematics with CT from the Indonesian government institution. Therefore, it is necessary to develop plugged mathematics+CT lessons.

This is stage 2 when we develop the lessons. In developing the lessons, the authors drafted the activities (draft 1) and shared them with the mathematics teachers and practitioners. The mathematics content is based on the Indonesian curriculum for junior high school students, area of circles and related circle-area problems. In this study, students would learn an area of a unit circle by approaching it by an area of an inscribed regular polygon or it is called Archimedes' exhaustion method see [19]. By online discussion, and experiencing the activities, the teachers and the practitioners provided feedback for improvement. Based on that, draft 1 evolved into draft 2. The changes from draft 1 to draft 2 will be provided in the result.

This is stage 3 after we implemented draft 2 to a few students, we evaluated and reflected on what happened in the classrooms. The students belong to participating mathematics teachers in the development stage. Seventeen junior high school students participated in this pilot experiment. They worked on the lessons in the GeoGebra applet. Their ways of solving the problems helped us to see if our design worked or did not work. We learned from this pilot to improve the lessons to draft 3. This draft 3 would be disseminated in the mathematics teachers' training.

B. *Data Collection and Analysis*

Data were collected from the mathematics teachers' and practitioners' feedback; students work on the GeoGebra and screen video recording. The feedback from the discussions was used to refine draft 1. The students' challenges or difficulties in solving the problem would be considered to revise the activities or to make it smoother for students in the next implementation. Thus, content analysis was used to help us to refine the lessons. We follow the content analysis steps by Krippendor [20] to analyze data by making, categorizing, and concluding the codes. For instance, students could create a program without a slider by pressing the run button 1 time and not pressing the clear button, it is coded as SNsR1C0. This code stands for "Successful with No slider, pressing 1 Run and 0 Clear".

V. RESULT

The following is the result of the changes in our lessons to help students learn programming and debugging. We would provide the most significant changes from draft 1 to draft 2.

A. *Menu Bar and Command*

Draft 1 showed the menu bar but this feature was later hidden in draft 2. To focus on the input bar, the menu bar is hidden. Interestingly, one of the practitioners responded what is B' so that students directly used B' without any information about B'.

Practitioner : *the circle constructed will not be fully visible and there is no information about B'.*

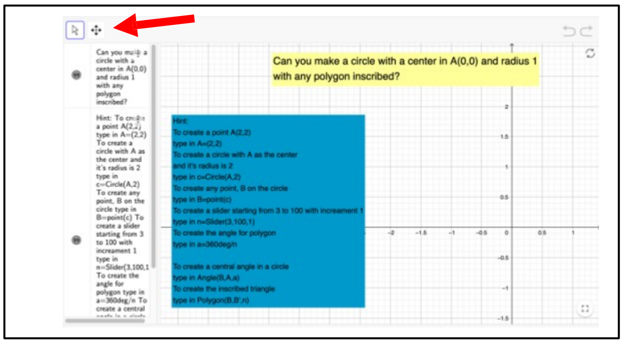


Fig. 2. Draft 1 with menu bar visible and no information about B'

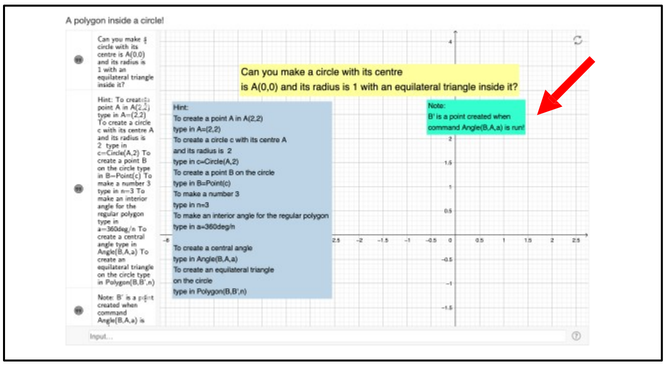


Fig. 3. Draft 2 without the menu bar visible and with the information about B'

B' is a dependent point when creating an angle from B to A with an angle measure a. After students typed in "Angle(B,A,a)", B' will be created and shown on the screen.

In draft 1, students did not learn how to input a command to find the area of the circle. In draft 2, students learned "Area(c)". By having this command, the area of the circle is visible to students. Therefore, students could see the area of the circle.

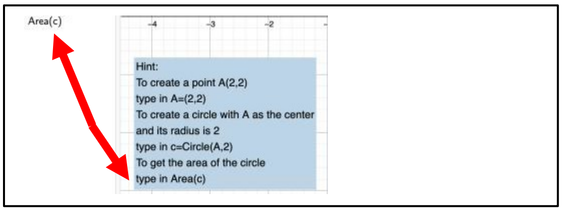


Fig. 4 A new command in draft 2 for the area of a circle

B. *Additional Task*

Another task was also added to let students experience like a programmer. The researchers, teachers, and practitioners agreed to add this task.

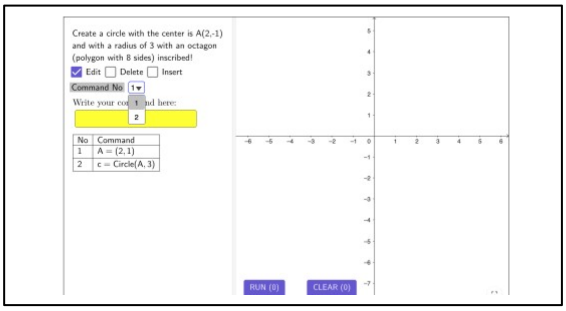


Fig. 5. The additional task on draft 2

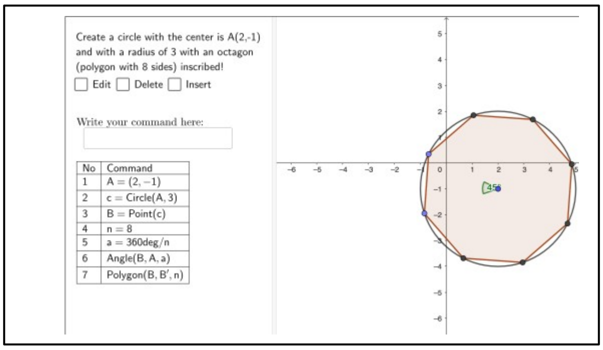


Fig. 6 Successful student programming

C. *Students' Responses*

Most students (14 out of 17) could solve the additional task and construct an inscribed polygon in a circle. Most of them did not use a slider as probably the task did not trigger them to do so. Only three students used a slider (Table 1). Most of the students ran the program after entering all the commands and never clicked the clear screen as their inputted program(s) was successful.

TABLE I. CODES AND RESPONSES

No	*Code*	*Response*	*Run*	*Clear*
1	SNsR1C0	6	1	0
2	SNsR2C0	2	2	0
3	SNsR5C0	1	5	0
4	SNsR6C0	1	6	0
5	SNsR16C0	1	16	0
6	SSR1C0	2	1	0
7	SSR0C0	1	0	0
8	FR10C0	1	10	0
9	E	2	0	0
	Total	17		

The following is the student's work on task 33. He failed to construct the requested objects and it is coded FR10C0. He ran the program 10 times and never pressed the clear button. This student created an octagon with B(3,-1) where B was not attached to the circle. B should be a point created on the circle by writing 'B=Point(c)'. Clearly seen in Figure 7, the polygon is not attached to the circle. The previously drawn circle was not erased or cleared yet, so it is visible to have a big circle with a radius of 6.5. However, the first two commands are correct. The fourth command was correct but as B is incorrect, it did not produce the desired polygon.

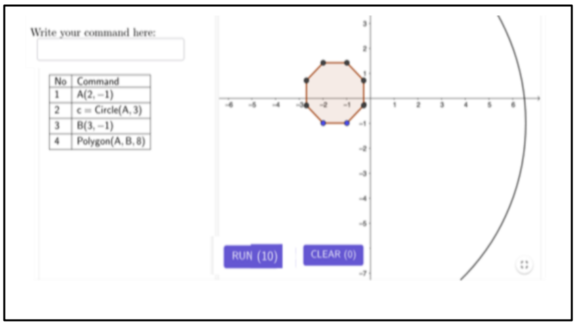


Fig. 7 An example of student's failure (FR10C0)

D. *Pop-up Window*

GeoGebra notifies its users when the command is incorrect. Our students also received that notification in the form of a pop-up window. This example is one of the tasks to do debugging.

Fig. 8 Pop-up window as an immediate-style interruption

Our students also received that notification in the form of a pop-up window. This pop-up window triggered students to check the "Poligon" as it is an unknown command. In Figure 9, students who understood this would revise the command into Polygon(A,B,n).

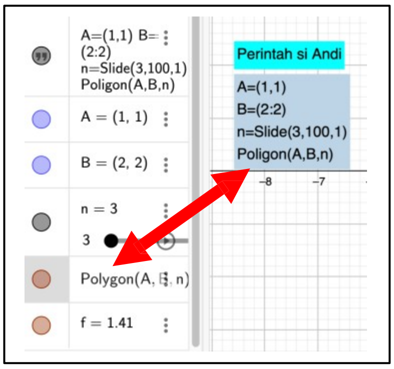


Fig. 9 Successful debugging

The following is the student's work on writing what they fixed on the incorrect commands. Most students could write the correct commands. The complete commands were written again. It showed that this student knew what he fixed.

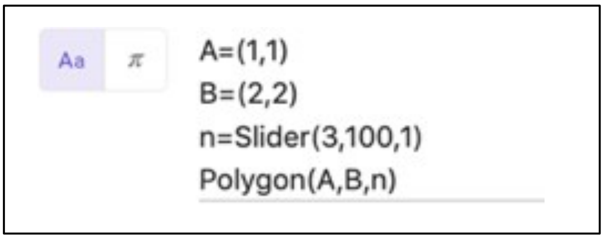


Fig. 10 Rewriting the commands that the student fixed

VI. Discussion

We witnessed that through collaboration with mathematics teachers and practitioners, our GeoGebra-based mathematics+CT lessons improved. It is relevant to the methodology we used, as the product of this phase could be more applicable see [5]. An additional task was developed to let students experience as a programmer. There are improvements in the color, position, and content from draft 1 to draft 2. We learned from this stage that getting the mathematics teachers' and practitioners' perspectives who would later implement the lessons provided us valuable input to improve the lessons. For instance, the missing information that the researchers drafted related to B'. As they put their experiences, they recognized that B' is necessary to be informed to make it understandable for students.

Regarding the constructionist theory, the activities, or tasks that students worked on supported students to gain knowledge. Similar to [6], students in our study interacted with the GeoGebra applet consisting of mathematical content to be solved. Most students in the end could construct an regular polygon inscribed in a circle. Students engaged with the programming and debugging and learned from those as well as from the pop-up interruption. They inputted the commands and learned from previous tasks to accomplish the final task (task 33). Students' engagement is visible throughout the screen recording videos.

We created the GeoGebra activities to let students program and debug. Most of the students could program by inputting the commands to construct the objects. In the last task, most students followed the order of inputting the commands by making point A, making circle c, making point B, making n, making an angle measure, making an internal angle, and making the polygon. At least students had to input seven commands to successfully create an inscribed polygon in a circle. Thus, our study witnessed students learn mathematics as well as computational thinking: programming. A similar study on college students also showed that students learned mathematics and programming [21]. Their study used both block and text programming to learn college algebra. Additionally, a similar study that use GeoGebra provided evidence that this software could support students' generalization and algorithmic thinking [8]. What differs in our study is that students could look back to previous tasks if they needed help. We assume that seeing only how to create an inscribed polygon in the previous tasks is not sufficient. The coordinates of points A and B, the radius of the circle, and the number of sides are different from previous tasks, so task 33 required students to adjust. Thus, they did not ultimately mimic the previous tasks.

Another CT facet we highlight in this paper is debugging. Despite the debugging when doing programming, our study explicitly provided students with tasks that they need to detect, recognize, and fix the errors. GeoGebra could accommodate the negotiated-style interruption and immediate-style interruption which these terms were coined by [17]. With the help of the pop-up window, most students could fix the errors. In [17], the immediate style of interruption would not be good for students as they probably will be dependent on this pop-up window. Our study has negotiated-style interruption and immediate style of interruption. Combining both interruptions in our study showed productive struggles for students. However, we realized that we should not put many errors at the start.

VII. Concluding Remark and Further Study

Collaborating with mathematics teachers and practitioners benefited our lessons to be more applicable. We learned that GeoGebra is promising to provide students with programming and debugging activities. GeoGebra can be set up as a learning environment or applet to let students experience programming in learning mathematics. Students who are not familiar with debugging should be given fewer errors to avoid frustration. This study is limited to a specific mathematics topic, and this may differ in different topics. Implementing these lessons to a broader group of students would be our next study.

Acknowledgment

The first author would like to thank the OeAD scholarship for supporting him to pursue a PhD study at Johannes Kepler University Linz. This paper is a part of his study.

References

[1] J. M. Wing, "Computational thinking," *Communications of the ACM*. 2006, doi: 10.1145/1118178.1118215.

[2] S. Bocconi *et al.*, "Developing Computational Thinking in compulsory education," in *Proceedings EdMedia 2016*, 2016, doi: 10.2791/792158.

[3] W. K. Ho and K. C. Ang, "Developing computational thinking through coding. Electronic Proceedings of the 20th Asian Technology Conference in Mathematics, 16 – 20 December 2015," 2015, pp. 73–87.

[4] T. Bell, J. Alexander, I. Freeman, and M. Grimley, "Computer Science Unplugged: School Students Doing Real Computing Without Computers," *J. Appl. Comput. Inf. Technol.*, vol. 13, no. 1, 2009.

[5] S. McKenney and T. C. Reeves, *Conducting Educational Design Research*. 2018.

[6] S. Papert, *Gears of My Childhood:Mindstorms: Children, Computers, and Powerful Ideas*. New York: Basic Books, 1980.

[7] J. M. Wing, "Research Notebook: Computational Thinking-What and Why?," *The Link Magazine*, 2010. https://www.cs.cmu.edu/link/research-notebook-computationalthinking-%0Dwhat-and-why (accessed Mar. 20, 2023).

[8] S. P. van Borkulo, C. Chytas, P. Drijvers, E. Barendsen, and J. Tolboom, "Computational Thinking in the Mathematics Classroom: Fostering Algorithmic Thinking and Generalization Skills Using Dynamic Mathematics Software," *ACM International Conference Proceeding Series*. 2021, doi: 10.1145/3481312.3481319.

[9] S. P. van Borkulo, C. Chytas, P. Drijvers, E. Barendsen, and J. Tolboom, "Spreadsheets in Secondary School Statistics Education: Using Authentic Data for Computational Thinking," *Digit. Exp. Math. Educ.*, Mar. 2023, doi: 10.1007/s40751-023-00126-5.

[10] A. Yohannes and H. L. Chen, "GeoGebra in mathematics education: a systematic review of journal articles published from 2010 to 2020," *Interactive Learning Environments*. 2021, doi: 10.1080/10494820.2021.2016861.

[11] D. Juandi, Y. S. Kusumah, M. Tamur, K. S. Perbowo, and T. T. Wijaya, "A meta-analysis of Geogebra software decade of assisted mathematics learning: what to learn and where to go?," *Heliyon*, vol. 7, no. 5, 2021, doi: 10.1016/j.heliyon.2021.e06953.

[12] N. A. H. Hamzah and R. Hidayat, "The Role of Geogebra Software in Mathematics Education: A Systematic Literature Review," *J. Pendidik. Sains dan Mat. Malaysia*, vol. 12, no. 1, 2022.

[13] S. Subramaniam, S. M. Maat, and M. S. Mahmud, "Computational thinking in mathematics education: A systematic review," *Cypriot J. Educ. Sci.*, vol. 17, no. 6, pp. 2029–2044, Jun. 2022, doi: 10.18844/cjes.v17i6.7494.

[14] D. Weintrop *et al.*, "Defining Computational Thinking for Mathematics and Science Classrooms," *J. Sci. Educ. Technol.*, vol. 25, no. 1, 2016, doi: 10.1007/s10956-015-9581-5.

[15] K. Brennan and M. Resnick, "New frameworks for studying and assessing the development of computational thinking," in *Proceedings of the 2012 annual meeting of the American educational research association*, 2012, pp. 1–25.

[16] V. J. Shute, C. Sun, and J. Asbell-Clarke, "Demystifying computational thinking," *Educ. Res. Rev.*, vol. 22, pp. 142–158, 2017, doi: 10.1016/j.edurev.2017.09.003.

[17] T. J. Robertson *et al.*, "Impact of interruption style on end-user debugging," in *Conference on Human Factors in Computing Systems - Proceedings*, 2004, doi: 10.1145/985692.985729.

[18] C. Kynigos, "Constructionism: Theory of Learning or Theory of Design?," in *Selected Regular Lectures from the 12th International Congress on Mathematical Education*, 2015.

[19] A. King, "Mathematical Explorations: Finding Pi with Archimedes's Exhaustion Method," *Math. Teach. Middle Sch.*, vol. 19, no. 2, 2013, doi: 10.5951/mathteacmiddscho.19.2.0116.

[20] K. Krippendor, *Content Analysis An Introduction to Its Methodology Second Edition*. 2004.

[21] M. Friend, A. W. Swift, B. Love, and V. Winter, "A Wolf in Lamb's Clothing: Computer Science in a Mathematics Course," 2023, doi: 10.1145/3545945.3569736.

PARTICIPATORY DESIGN OF A HIGH-FIDELITY PROTOTYPE OF AN ESSENTIAL LEARNING CURRICULAR TOOL

Bianor Valente
CIED, Escola Superior de Educação de Lisboa
Insituto Politécnico de Lisboaline)
Lisboa, Portugal
bianorv@eselx.ipl.pt
https://orcid.org/0000-0001-6541-8000

Maria João Silva
CIED, Escola Superior de Educação de Lisboa,
Instituto Politécnico de Lisboa
Lisboa, Portugal
mjsilva@eselx.ipl.pt
https://orcid.org/0000-0003-1017-8315

Pedro Sarreira
CIED, Escola Superior de Educação de Lisboa
Instituto Politécnico de Lisboa
Lisboa, Portugal
pedros@eselx.ipl.pt
https://orcid.org/0000-0002-5775-1820

Abstract— In the context of the AE.Maps project (IPL/2022/AE.Maps_ESELx) – Essential learnings: mapping to promote curriculum integration – this paper presents the design of a high-fidelity prototype of a tool to support pre-service and in-service teachers, during curricular vertical and horizontal articulation. This tool should make it possible to query a database of Essential learning (EL), using a user-friendly interface. The four-stage double-diamond model was used to guide the participatory design process. In the discovery phase, through task analysis and focus group, involving 51 pre-service and in-service teachers, user needs regarding EL search were gathered. In the exploratory and definition phase, problems were explored and defined, while personas were created. In the development phase, sketches made by different participants were used to develop and explore solutions for a friendly interface. Moreover, during this phase, an Excel medium-fidelity prototype was implemented, and a high-fidelity prototype was iteratively designed in a participatory way.

Keywords—Participatory design, elementary education, database, interface, curricular orientations,

I. INTRODUCTION

Recently, in Portugal, a new curriculum was designed. This process involved, among other measures, the definition of a common set of learning outcomes for every student – the Essential Learning (EL) and implied the effective recognition of schools as a level of curricular decision-making, responsible for the contextualized implementation of the national common core curriculum [1]. In this level of curricular decision-making, teachers are the critical actors [2], [3]. However, recent data indicate that teachers report weaknesses in curriculum management related to the reading, interpretation, and operationalization of EL, regarding links to other levels of education and, above all, between the EL of various subjects [4]. This is an important problem, because according to OECD (2020) [5], "When it is difficult to navigate through the curriculum, teachers are more likely to misunderstand its intent and use it ineffectively" (p.15).

The AE.Maps project (IPL/2022/AE.Maps_ESELx) – Essential learnings: mapping to promote curriculum integration – aims at supporting in-service and pre-service elementary school teachers in the horizontal and vertical curriculum articulation process, namely through the development of a high-fidelity prototype, which will integrate a database for an interactive search and query of the EL documents. This is quite relevant since many recommendations stress the need to demonstrate connections between subjects.

Considering the need to develop a tool to support teachers in the interactive search and query of EL, it is important to remark that the mentioned tool should be useful, evidencing utility and usability, since the quality of the design of computer-based products is related to the utility and usability of such products. Furthermore, any computer-based tool should have a "friendly" interface. More than making easy and transparent the user-tool interactions, an interface should support thinking and the discovery of new patterns in the tool world [6].

The user interface is the set of inputs and outputs controlled by the user and the technological system, composing the interactive activity. It includes the appearance, but also the reified ideas of user-system interaction [7].

In this context, the study presented in this paper aims at the participatory design of a high-fidelity prototype of a useful tool, with a "friendly" and thought-provoking interface, to query a database of Essential learning (EL), during horizontal and vertical curriculum articulation.

The paper starts with this introduction, continues with the presentation theoretical and empirical context, the results, and closes with the conclusion and bibliographic references.

II. THEORETHICAL AND EMPIRICAL CONTEXT

A. *Curricular orientations and management in elementary school in Portugal*

In Portugal, in the last 25 years, there has been a succession of curricular changes, resulting from the lack of consensus on what is considered to be learned in each historical and social period [1], [8]. Not only have there been frequent changes, but documents with different guidelines, elaborated in different periods, with a lack of coherence between them and sometimes with contradictory rationales, have also coexisted. These inconsistent curricular documents created difficulties, not only in horizontal, but also in vertical articulation.

In 2015, a new government, with a different understanding of what curriculum policy should be, began a process of curricular changes. Firstly, a Students' Profile by the End of Compulsory Schooling (SP) [9] was defined (Order No. 64787/2017, of 26 June). The SP is a document that describes the vision, principles, values, and skills that students, upon completing compulsory schooling, must have developed and that are fundamental for building a culture and a country that is humanistic, scientific, and artistic. Secondly, schools were given some autonomy to meet their specific needs (e.g. pedagogical differentiation, new disciplines, interdisciplinary and project work) and curricular flexibility (Decree-Law n.º 55/2018, of July 6th and Ordinance n.º 181/2019, of June 11th). Finally, with the aim of solving the extensive curricular overload, new reference curricular documents called Essential Learning (EL) were prepared. EL are the result of a careful selection of a common set of knowledge to be acquired, as well as skills and attitudes to be developed by all students, in each subject area or discipline (Decree-Law No. 55/2018, of July 6). The development of these documents began in 2016, through an invitation made by the Ministry of Education (ME) to teachers' associations, scientific societies and programs' authors [10].

This process culminated in the publication of Dispatch n.º 6605-A/2021, of July 6, which determined that the EL, in convergence with the SP, should become the basic reference for decisions associated with flexibility and curriculum management by schools and teachers, revoking all previous curricular programs and goals. Due to an in-depth analysis of failure in the mathematics subject (Order n.º 12530/2018, of December 28, amended by Order n.º 7269/2019, of August 16), a curricular review of the EL for this subject was carried out (Dispatch n.º 8209/2021, of December 15). Thus, currently, we have a long-desired situation in terms of curricular reference, without the proliferation of documents from different eras and with different logics.

Recently, an evaluation of the implementation of EL was carried out [4] through a questionnaire to teachers at national level, interviews with teachers, parents, and students and also the analysis of curriculum planning. This study concluded that most of the surveyed teachers consider that the EL are better adapted to the needs of the students than the previous curriculum documents, allowing greater flexibility in the management of the curriculum, namely in processes of pedagogical differentiation. However, some teachers consider that the language used in the EL creates difficulties, reducing its use. Most teachers still evidence difficulties, namely "in recognizing the contribution of each subject to achieve the SP, in identifying knowledge, skills and attitudes that must be developed by all students, in understanding the suggested examples of strategic teaching actions" [4, p.11].

B. *Participatory design of a useful tool*

This research uses techniques of the participatory design method to design a useful tool, with a friendly user interface to support teachers in curriculum vertical and horizontal articulation, through the query of a database of EL. Participatory design (PD) is the design of computer-based products with final users as full participants [11].

The quality of the design of computer-based products is related to the utility and usability of such products. In other words, a computer-based system/product is useful when it shows usability and utility.

Utility is related to the functionality of the system/product, to whether the system/product performs the functions you need. According to [12], utility refers to whether the system provides the features needed by the user.

Furthermore, usability is related to easiness of the use of a system/product by the user and to how pleasurable that use is. Reference [12] defines usability relating it to how easy and pleasant is the user experience, making explicit five quality components of usability: Learnability; Efficiency; Memorability; Error minimization; and Satisfaction.

In this way, this research aims at developing a high-fidelity prototype of a tool to support teachers in the interactive search and query of EL, assuring its usefulness, through the investment in its utility and usability.

III. METHODOLOGY

The double diamond model [13] was used to guide the participatory design process. This model divides the design thinking process into 4 stages: discovery, where problems are explored, user needs gathered and ideas generated (divergent thinking); definition, where problems are defined and refined (convergent thinking); development, where solutions are created and explored (divergent thinking); and delivery, where the solution is tested and evaluated (convergent thinking). The first divergence-convergence process aims at designing the right thing, while the second aims at designing the thing right. The study presented in this paper is focused on the first three phases.

C. *Discovery Phase*

During the first phase, and to get insight in the (future) teachers' perceptions and needs, different research methods were used. We conducted a task analysis (TA) with 27 students enrolled in the last year of the Bachelor in Basic Education and with 7 future teachers enrolled in the last year of a 2-year master's program in a Portuguese School of Education (4 in the master in Teaching the 1st Cycle of Basic Education and Mathematics and Natural Sciences in the 2nd Cycle of Basic Education, and 3 in the Master in Teaching the 1st Cycle of Basic Education and Portuguese Language and Portuguese History and Geography in the 2nd Cycle of Basic Education). In the task analysis future students were asked to perform different types of curriculum articulation and, to do that, they had to search in the EL documents with different goals. Students were also asked to think aloud, while performing the curriculum articulation. Thinking aloud is a method that elicits verbal reports of thinking and can be combined with other qualitative methods [14].

We also conducted focus groups (FG) with 17 teachers and with 7 future teachers. Of the 17 teachers, 1 is a special education teacher, 8 teach in the 1st Cycle of Basic Education (CBE) and 8 in the 2nd CBE (5 taught Mathematics and Natural Sciences and 2 Portuguese and History and Geography). The aim of the focus group sessions was to gather data about: (1) how participants evaluate the actual page where EL are made available, (2) which functions they believe would help them to increase vertical and horizontal curriculum articulation.

D. *Second phase*

During the second phase, the data from the task analysis and focus group were transcribed and analyzed using a general inductive analysis [15]. Based on research, and through problem definition methods, the problem was redefined. Moreover, 6 students (3 man and 3 women) enrolled in the first year of the bachelor's in visual arts and Technology, also analyzed data collected during the first phase and developed personas.

E. *Third phase*

During the third phase and for the creation and exploration of solutions, in a quick and inexpensive way, we used sketches to co-design, in a free and divergent way. Sketches are used in initial "early divergent stages of the design process" [16]. Sketches are not technically prototypes, but they are very important in creating and exploring multiple initial ideas, since they are fast to create, cheap and disposable [16].

First, a medium technology prototype [11], built in Excel by the authors, was used with the pre-service teachers, enrolled in the last year of the Bachelor in Basic Education, to test the database functionalities (queries), making explicit the possible involved variables in common didactic planning tasks. After a familiarization with the data and variables future teachers were asked to sketch the initial menus of the tool to query EL.

IV. RESULTS

F. *Discovery phase*

A.1.Task Analysis

When faced with the need to solve tasks that involved consulting the EL, the participants adopted different strategies.

The first difference concerns the way in which they accessed the EL: some groups consulted the EL stored on their own computer while others googled the expression “essential learning” and opened the page of the Directorate-General for Education (Direção-Geral da Educação) of the Portuguese Ministry of Education.

The existence, on the personal computer, of a folder with the EL for the different years of education levels is, according to one participant, a consequence of the need to access the EL, even in the absence of internet access.

The second difference is related to the strategy used to search inside the documents. Four groups, all comprising undergraduate students, proceeded to read the entire content of the EL. The other four groups (2 bachelor’s groups and 2 Master's groups) searched for a word or an expression, using the find tool in the PDF. As for the words/expressions used, different attempts were made, depending on the answers obtained. For example, in a task that aimed to verify if in grade 4 students should learn the circle area, the following steps were carried out: i) using the PDF Find tool, the student wrote the expression “circle area”; ii) as there were no results, she searched again, but only for the word “area”; iii) in face of several results («circles of fractions»; «blocks of circles of fractions»), the student mentioned that it was necessary to «distinguish circle from circumference» and wrote «circumference» in the Find tool of the PDF.

During the task analysis, students made different comments that denote not only the relevance and frequency of this type of task, but also the low efficiency associated with the chosen strategy:

P3- Yes… Trial and error.

P2- And this happens often. We want to find a content and we must open all the 1st Cycle EL to find out in which year that content is in. We have an idea, for example «in the 3rd or 4th», but we must open both documents to compare (Master students, TA1)

A.2.Focus Group

During the focus groups participants pointed positive and negative aspects to the way EL are made available. It is also important to mention that some teachers revealed that they had never reflected on how the EL are organized and made available: “I never thought about whether this could have another organization” (P2, FG6); “That's what I was going to say, I had never thought about it” (P4, FG4).

A.2.1. Positive aspects

Most participants indicated that it is very easy to access the portal of the Directorate-General for Education, where the EL are available. According to one future teacher: “I immediately search on the Internet for «essential learning in the first cycle» and this table immediately appears. I think it's easy, in my opinion. (E1, Master student, FG1) (Fig.1).

The positive assessment regarding the accessibility of the webpage is the reason why one teacher, that initially choose to print the EL, change her practice:

> When they came out in this format, I printed them (…) I worked a lot on paper, but after that I began to realize that it took a lot of time (…) So I started to consult more here [on the site]. (...) It is accessible, it is something that is accessible, at any time, by anyone, at any time. (P3, FG7).

The fact that the documents can be downloaded very easily is also another positive aspect. As one teacher says: “From the point of view of downloading the PDFs and storing them on our computers, it is good” (P2, FG5).

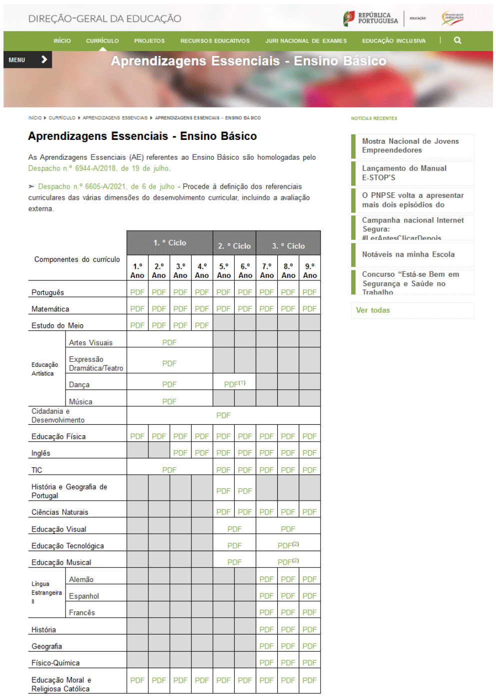


Fig. 1. Webpage of Directorate-General for Education with the EL.

The existence of a double-entry table, crossing the year and the curriculum component, was valued by some participants, as it allows the user to have a holistic view of the curriculum. This appreciation was more audible among future teachers than among teachers, which may be a consequence of the different levels of knowledge that these participants have about the curriculum and its organization.

> P2- And I think this [webpage] is super functional. You see the year; you see the discipline, and everything is there (P2, master student, FG1)

> Yes, yes. I also think so. I think it has a very clean and very objective vision and even for those who are starting to use

this document, we can immediately understand that the Environmental Studies only exists in the 1st Cycle and does not continue (P3, master student, FG2)

A.2.2. Negative aspects

In all focus groups, criticisms emerged. However, in some cases, these evaluations only appeared after specific questions about the impact of the site's organization on the vertical and horizontal articulation.

Some teachers highlighted, as a less positive aspect, the graphical component. For example, for a teacher "This page is very uncomfortable. Graphically, it's horrible. It makes no sense" (P2, FG5). Future teachers also highlighted this aspect; yet they didn't value it too much:

P3- It's not pretty, but it doesn't have to be.

P1- But it doesn't have to be, exactly.

P2- It must be functional.

P3- Yes, it must be functional, it must be practical. (FG1)

The way information is fragmented, having one document per year and per subject, was a criticism made by many participants, especially by teachers. The difference between having access to and being able to navigate and compare is quite evident in the following excerpt:

P2: This page does not help us at all, neither within the discipline itself nor within the cycle.

P1: That is, it gives us access to the document, but in terms of exploration we must explore it alone and understand, interpret. (FG6)

One teacher even established a causal relationship between the experienced articulation difficulties and the way the page is organized. According to her: "perhaps our difficulty came from that page since everything is so divided. Things are not integrated" (P2, FG6).

A.2.3. User needs and suggestions

Following some criticisms, the participants began to identify needs that were not fulfilled with the current interface, and that will imply greater interactivity.

The need to establish and visualize curricular articulations, both vertically and horizontally, was one of the most mentioned. Nevertheless, reflections were different according to each type of articulation.

The vertical articulation was more discussed among teachers than among future teachers. This analysis is closely associated with knowing that curriculum follows a spiral pattern, which encourages reinforcement of previously learned concepts, and the conviction that having roadmaps illustrating those progressions would support instructional planning. As one teacher says, to ensure deep learning, it is not sufficient to know only the curriculum being taught in her grade; there is a need to understand what the students learned before, and what they will need learn after:

I would like to get a sense of what the students worked on in previous years. And if it's a spiral, I think it's important to understand what was worked in the 1st, 2nd, 3rd and 4th grade. And I felt this need this year, in the 5th grade, to look back, for example, to what they had been working on, regarding statistical knowledge and rational numbers. (P3, FG4)

Not only do the teachers verbalize this need, but they also recognize the need for resources with these roadmaps, because the preparation of these progressions by teachers is difficult and time-consuming:

In one of the sessions of the in-service training of the Mathematics EL, the trainer asked us to make a roadmap regarding the decimals, fractions, and percentages, from the 1st to the 9th year. And it was very difficult (...) a terrible difficulty (...) This vertical analysis would really make perfect sense here (P2, FG4)

To operationalize the visualization of the vertical articulation, different hypotheses emerged. Some teachers mentioned the possibility of doing it based on the domains/organizers: "putting on the same grid, for example, in terms of Portuguese, «orality», «oral production», «oral comprehension», and putting the four years side by side (...) it would be easier to read" (P2, GF7). Other teachers and future teachers considered that it would be important to see how the contents/concepts evolved over the years.

As for the graphical solution, the construction of comparative tables was the most invoked suggestion. The suggestions both seem to refer to static tables, which could be consulted according to an existing list, but also to interactive tables, made as a result of requests made by the user ("For example, we could search for a concept and understand the progression it has over the years").

Although the table was the more invoked format, one teacher highlights the importance of having different graphical solutions (like a frieze, a spiral) and the possibility to choose the one each teacher prefers, because "we teachers, we are not all the same" (P4, FG4).

Other articulations were also discussed. For example, for some teachers it would be nice to improve the connection between the SP and the EL. According to one participant: "Clicking on a button for this competence, «interpersonal relationship», it would appear, the EL that develops this competence, so that the teacher can better focus or prepare the work throughout the year. (P13MCNCI).

In order to provide greater interactivity, the participants mentioned different functionalities, such as a search box, filters (for year, area, cycle) and hyperlinks. The search box was mentioned by both teachers and future teachers.

P1- you write a keyword, and it will open a series of pages that contain that keyword (...) I put «astrology», hit Enter, and it said astrology detected on the following pages: 1st Cycle, EL of grade 2, for example. And we easily went and found the document.

The hyperlinks were mentioned as a possible solution to the need to explain some concepts and ideas in more detail: "there is a word that is underlined (...) that take us to other documents, or even in the document itself leads us to another explanation that is further down, or elsewhere in the document" (P3, FG1). According to a teacher, it is astonishing "how today, being so easy to build interactive internet pages, how is it possible that the EL is not presented with links, with "linked" words (P2, FG6).

G. Definition

Data collected through task analysis and focus groups, during the discovery phase, helped us build a clear picture of the problem. First, we found confirmation that (future) teachers often face challenges while searching the EL. Second, we found evidence that the webpage where the EL are made available is at least, in part, responsible for those challenges.

Based on research, the problem was redefined. Teachers need to visualize learning progressions and the articulations between subjects to be able to promote more meaningful learning, but EL are organized by year/cycle and by subject and searching EL this way is difficult and time-consuming.

Moreover, the following "how might we" questions were formulated: how might we make the process of searching EL easier, so teachers can see connections between subjects? How might we make learning progressions evident, so that teachers feel more confident in their teaching choices?

The information collected also helped to create personas. These personas were created during one course of the bachelor's in visual arts and Technology - user-centered design course. Three subgroups of users were created, expressing the needs, desires, and behaviors of specific groups: one pre-service teacher, more concern with searching the EL for academic tasks, especially to easily find the main contents for each year in each subject and to select possible topics for curricular projects; one in-service primary teacher, responsible for teaching all subjects, more concern with searching EL from different years, in an easy and rapid way, mainly because she has a mixed-grade class; one in-service teacher, teaching Natural Science in grade 5 and 6, more concerned with integration of curricular contents from different subjects within grade 5 and grade 6 and also with what students are supposed to learn in Science during the 1st Cycle to improve teaching coherence.

H. Development

The pre-service teachers, in the last year of the Bachelor in Basic Education, and who were familiarized, through the Excel medium technology prototype, with variables related to common didactic planning tasks, were asked to sketch the initial menus of the tool to query EL. The obtained sketches were diverse, with different numbers of search variables, types of menus (drop-down or fixed menus, top or side bar menus, all-screen menus…), and types of results (goals, activities, resources…). Nevertheless, in all the sketches, the designed interface was easy to use (simple menus), clean (sufficient space, consistent elements, and visual language), and had a set of common variables (Fig. 2).

Global interface metaphors were created in two of the sketches. One sketch used an EL train metaphor, in which the menus were integrated in the carriages, and another one used a living room metaphor, in which the menus were integrated in paintings, thematic books, bibelots, and storage boxes (Fig. 3).

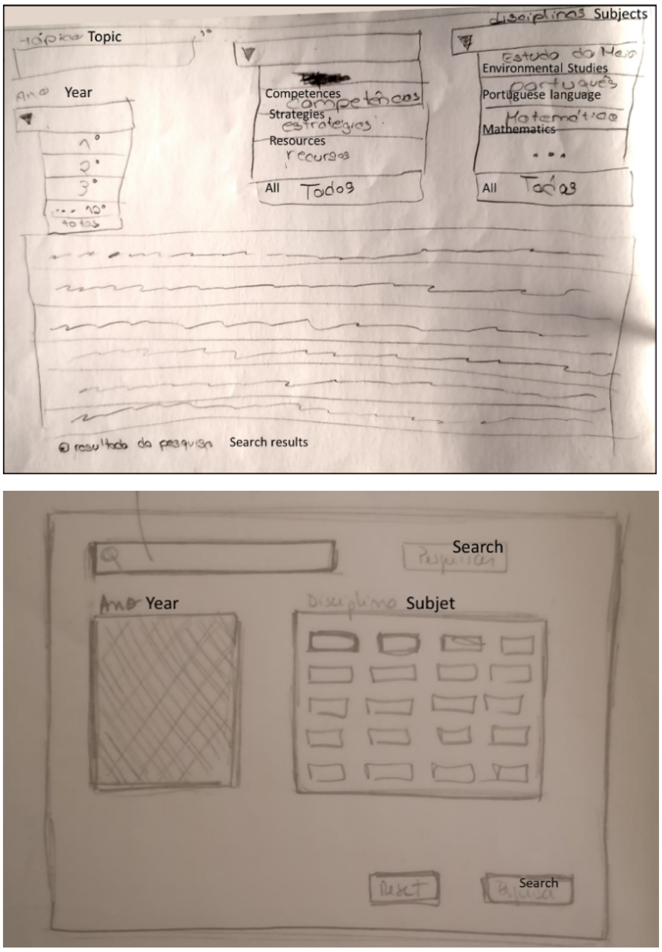


Fig. 2. Examples of sketches with a search box and different filters.

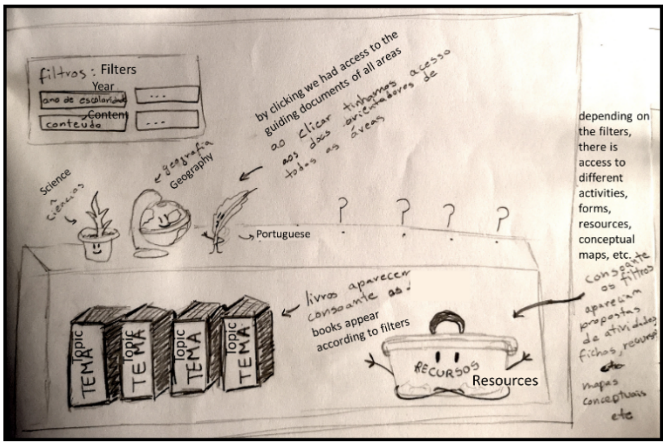


Fig. 3. Example of a sketch, using a global and specific metaphors.

The developed sketches supported the definition of a sketch of the high-fidelity prototype's interface (fig. 4). The most frequent variables in the sketches were selected and the layout was designed to allow different levels of research.

In the high-fidelity prototype's interface, the user should start by selecting the year(s)/level(s) of scholarity. Following this first selection, the correspondent subjects are presented to be selected by the user. The correspondent Domains are, then, presented, and can also be selected by the user.

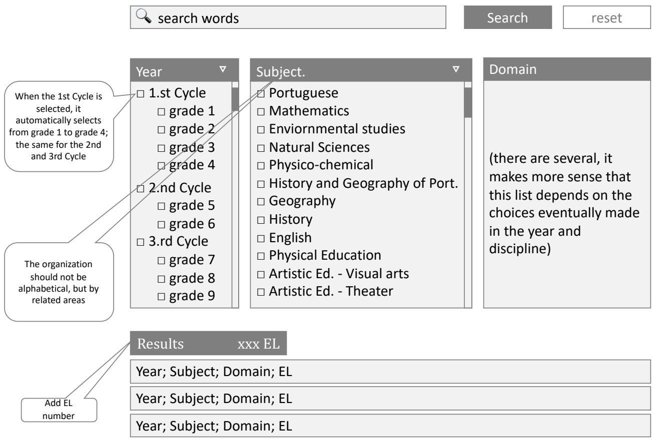


Fig. 4. High-fidelity prototype's interface.

V. CONCLUSION

The study presented in this paper designed a high-fidelity prototype of a tool (EL tool), to support pre-service and in-service teachers during curriculum vertical and horizontal articulation, making possible the querying of an EL database. The high-fidelity prototype is being implemented.

The "AEMaps Project" made use of a set of techniques of Participatory Design, from sketches to task analysis, and to a medium fidelity prototype, to validate the team ideas, learn stories with the users, co-construct artifacts, and test the implementation of selected functionalities.

The set of focus groups developed with pre-service and in-service teachers allowed stories-collecting to inform the future tool/prototype functionalities, through the contribution to the knowledge and understanding of product utility (Muller & Druin, 2012). These results informed the creation of the Excel medium-fidelity EL prototype.

Besides, the task analysis, performed using the thinking aloud method, also contributed to validating the Excel medium-fidelity EL prototype, which made explicit the variables, and their relations, needed in planning curricular activities.

To co-design of the interface of the high-fidelity EL prototype included the production of sketches by future users. Those sketches were created after the familiarization with the Excel medium-fidelity EL prototype variables. This way, regarding usability, the created sketches validated some of the previous ideas of the research team and elicit new ideas to the design of the high-fidelity prototype interface.

The Excel medium-fidelity EL prototype, together with the designed interface of the high-fidelity EL prototype, are the basis of the ongoing implementation of this final prototype, which will be tested in the near future. The final prototype will be assessed through qualitative in-person usability testing with pre-service and in-service teachers. The main idea is to collect data about how participants use the interface while performing specific tasks and listen for feedback.

Concluding, the participatory design described in this document was developed successfully, not only in what concerns the goal of designing a high-fidelity EL prototype, but also in the involvement and engagement of participant future users in their own learning contexts.

ACKNOWLEDGMENT

This work was supported by the Instituto Politécnico de Lisboa [IPL/2022/AE.Maps_ESELx].

REFERENCES

[1] M. C. Roldão, "Currículo e debate curricular atual – eixos e contributos para uma análise incompleta", in Práticas e discursos sobre currículo e avaliação: Contributos para aprofundar um debate, M. A. Flores, Ed. Santo Tirso: De facto, 2017, pp. 23–54.

[2] M. Fullan, Leadership and Sustainability – System Thinkers in Action, Issue 3, Thousand Oaks, CA: Corwin Press, 2005.

[3] J. Van den Akker, "Building bridges: how research may improve curriculum policies and classroom practices", in Beyond Lisbon 2010: Perspectives from research and development for education policy in Europe, S.M. Stoney, Ed. Aarau, Switzerland: CIDREE, 2010.

[4] F. Costa, A. Paz, C. Pereira, E. Cruz, G. Soromenho, and J. Viana, Relatório de Avaliação da implementação das aprendizagens essenciais. Instituto de Educação da Universidade de Lisboa, 2022. http://www.dge.mec.pt/noticias/relatorio-de-avaliacao-da-implementacao-das-aprendizagens-essenciais

[5] OECD, Curriculum overload: A way forward, Paris: OECD, 2020. https://www.oecd.org/education/curriculum-overload-3081ceca-en.htm

[6] M. Nielsen, Thought as a technology", 2016, available at http://cognitivemedium.com/tat/index.html

[7] A. Marcus, "Fast forward: Dare we define user-interface interface design?" Interactions, vol. 9, pp. 19-24, 2002.

[8] M.C. Roldão, Um currículo de currículos. Chamusca: Cosmos, 2011.

[9] G. O. Martins, Org., Students' Profile by the end of compulsory schooling. Lisbon: Ministério da Educação, 2017. https://cidadania.dge.mec.pt/sites/default/files/pdfs/students-profile.pdf

[10] S. Almeida, J. Viana, N. Barcelos, M. C. Roldão, and H. Peralta, "Collaboration between teachers' associations on the curriculum design of essential learning in Portugal", in Curriculum autonomy policies: international trends, tensions and transformations, A. Sílvia, F. Sousa, and M. Figueiredo, Eds. Interdisciplinary Centre of Social Sciences, School of Social Sciences and Humanities, NOVA University Lisbon, 2022, pp. 110–145.

[11] M. Muller and A. Druin, "Participatory design: The third space in human–computer interaction," in Human computer interaction handbook: Fundamentals, evolving technologies, and emerging applications, 3rd ed., J. A. Jacko, Ed., Boca Raton, FL: CRC Press, 2012.

[12] J. Nielsen, Usability 101: Introduction to usability. Nielsen Norman group, 2012. https://www.nngroup.com/articles/usability-101-introduction-to-usability/

[13] U. Davies, and K. Wilson, Design methods for developing services, UK: Design Council, 2011. https://www.alnap.org/system/files/content/resource/files/main/DesignCouncil_Design%20methods%20for%20developing%20services.pdf

[14] D. W. Eccles and G. Arsal, "The think aloud method: what is it and how do I use it?", Qualitative Research in Sport, Exercise and Health, vol. 9, pp. 514-531, 2017. DOI: 10.1080/2159676X.2017.1331501

[15] D. R. Thomas, "A general inductive approach for analyzing qualitative evaluation data," American Journal of Evaluation, vol. 27, pp. 237-246, 2006.

[16] R. F. Dam and T. Y. Siang, 5 Common low-fidelity prototypes and their best practices, Interaction Design Foundation, available at https://www.interaction-design.org/literature/article/prototyping-learn-eight-common-methods-and-best-practices

STEM Career Aspirations Among Portuguese Secondary School Students

Teresa Ribeirinha
School of Education
Polytechnic University of Santarem
Santarém, Portugal
Life Quality Research Centre
Rio Maior, Portugal
https://orcid.org/0000-0002-5678-3476

Marisa Correia
School of Education
Polytechnic University of Santarem
Santarém, Portugal
Life Quality Research Centre
Rio Maior, Portugal
https://orcid.org/0000-0001-6205-4475

Mónica Baptista
Instituto de Educação
University of Lisbon
UIDEF
Lisbon, Portugal
https://orcid.org/0000-0003-1609-5764

***Abstract*— The main objective of this study was to investigate the Science, Technology, Engineering and Mathematics (STEM) career interests of secondary school students in Portugal. Data were collected from a sample of 190 twelfth grade students, consisting of 106 females and 84 males, using the STEM Career Interest Survey. The results showed that interest in careers in engineering tended to be lower than interest in mathematics, science, and technology among secondary school students. The study also found a gender gap in students' interest in science, engineering, and technology careers. Female students were less interested in engineering and technology-related careers than their male counterparts, but more interested in science-related careers. These findings can inform education policy makers, curriculum developers, teachers, and researchers about the importance of STEM education in nurturing and cultivating students' interest in STEM fields.**

Keywords—career, interest, secondary students, STEM education

I. Introduction

Nowadays, an increasing number of occupations require a strong foundation in science, technology, engineering, and mathematics (STEM). Making informed decisions, both as individuals and as a society, increasingly relies on having a basic understanding of STEM. This encompasses understanding medical diagnoses, evaluating competing claims related to the environment, and effectively utilizing a wide range of computer-based applications in our daily activities [1]. The fourth industrial revolution brought enormous advances, such as artificial intelligence, augmented reality, quantum computing, big data, and analytics, but also numerous challenges. So, there is a pressing need to prepare students for the ever-evolving technological landscape of the fourth industrial revolution. This entails equipping students with a mastery of knowledge and skills in STEM-related fields, as well as fostering their interest in pursuing careers related to STEM [2].

However, there has been a noticeable decline in the enrolment of students in STEM fields of study in tertiary Education, especially in information and communication technologies (ICT); and engineering, manufacturing, and construction [3]. Recognizing this decrease as one of the most significant challenges for the future of Europe, there is a need to address the shortage of skilled individuals in these areas [4]. Moreover, although women constitute most of undergraduate students, on average across OECD countries, they are still under-represented in STEM. The shortage of STEM workers and the underrepresentation of both ethnic minorities and women have been extensively documented, as reported by UNESCO [5]. Even though gender gap was overcome in natural sciences, mathematics and statistics, other STEM fields remained critical, such as engineering and ICT [3, 6].

According to data from the International Labor Organization (ILO) [7], women constitute 38% of individuals holding STEM degrees, and they hold approximately 44% of the jobs in STEM fields, despite the fact that such jobs make up only 12% of total employment. The striking 24 percentage point gender gap in the number of STEM graduates in Portugal highlights the need for substantial progress.

Over the last decade, the Portuguese government and education policymakers have been working to strengthen STEM education by focusing on two key components: improving STEM curricula and teaching methods to make them both effective and engaging and promoting teacher education and professional development in STEM [8]. The national strategies have been aimed at 1) increasing the proficiency of all students and teachers in STEM, in order to improve the ability of students to address increasingly complex problems; and 2) increasing the number of students pursuing STEM careers and advanced studies by raising awareness of the importance of STEM and by stimulating interest in STEM subjects [8]. However, according to the General Directorate of Statistics for Education and Science data, in Portugal between 2016 and 2021, the post-secondary study paths chosen by students are social sciences, commerce and law, even though more than 50% of students choose science and technology at the end of the ninth grade [9]. In this context, the *Impulso Adultos* and *Impulso Jovens STEAM* programs, part of the ongoing Recovery and Resilience Plan (PRR 2021-2026) [10] were launched in Portugal, aiming to graduate over 18, 000 students through higher education in STEAM domains by the end of 2025, as compared to the total number of graduates in 2020. Additionally, they aim to qualify approximately 100,000 adults by the end of 2025, with the goal of increasing the percentage of higher education graduates among the population aged 30-34 to 50% by 2030, up from around 37% in 2020. This program also seeks to promote greater participation of female students in STEAM disciplines at the higher education level.

In this sense, understanding the factors that influence STEM subject choice is vital to encourage greater STEM participation and increase the number of STEM graduates and the prevalence of STEM skills in the labour force [11].

However, there is a notable scarcity of research examining the underlying causes of the declining interest in STEM among students, particularly when they are about to enter the tertiary level [12]. To fill this gap, it is imperative to develop a deeper comprehension of young individuals' perceptions regarding STEM careers. Consequently, the primary objective of this study is to offer an overview of the Portuguese context by investigating the level of interest in STEM careers among upper secondary students in Portugal, following educational reforms aimed at strengthening STEM education. Specifically, the study will focus on addressing the following research questions (RQ):

RQ1) What is the level of interest among secondary-school students in STEM careers?

RQ2) Do secondary-school students' interest in STEM careers differ across STEM fields?

RQ3) Does the interest in STEM careers among secondary-school students differ in terms of gender?

II. INTEREST IN STEM CAREERS

The "term interest describes the mind-set characterised by a need to give selective attention to something that is significant to a person such as an activity, goal or subject" (p. 69, [13]). Interest is one of the strongest predictors of STEM enrolment behaviour [13] and career orientation [14]. Furthermore, Gender represents a potential influential factor on students' STEM interests and career aspirations, with existing research indicating a tendency for male students to show more inclination towards STEM fields [15, 16]. On the other hand, female students often display a stronger interest in arts and education fields [15, 16]. This gender pattern is particularly noticeable in engineering, which tends to attract more male students [16], whereas females lean more towards medical/health and biology careers [17, 18].

In order to study the factors that influence interest in STEM careers, several instruments have been tested. Tyler-Wood et al. [19] developed two instruments, the STEM semantic survey and the STEM career questionnaire, which were validated using a sample encompassing junior high school students through to adults. The findings of their research demonstrate the efficacy of these instruments in gauging students' interest in STEM. However, it is important to note that while these surveys have been successful in measuring interest levels, they do not explicitly elucidate the factors that influence students' interest in pursuing STEM careers.

STEM Career Interest Survey (STEM-CIS) was developed by Kier et al. [20] to assess students' interest in STEM careers. The instrument was based on key aspects of the social cognitive career theory [21] (e.g., self-efficacy, outcome expectations, personal inputs, and contextual supports and barriers). STEM-CIS was used to gather data on the validity and interest of students residing in rural Southeastern America towards STEM careers. Additionally, research has been conducted in Turkey to test the STEM-CIS instrument validity and reliability of the STEM-CIS instrument using the confirmatory factor analysis (CFA) technique [22]. Several studies used this instrument to determine students' interest in STEM. Among them, Dönmez and Idin [23] applied it to 534 middle school students. The results indicate that middle school students' STEM career interests are influenced by factors such as self-efficacy, personal goals, outcome expectations, interest in science, contextual support, and individual inputs. The study also revealed that STEM career interest is not dependent on gender, but it does vary according to the students' grade level. Also, in Turkey, another study [24] applied this instrument to a larger sample (892 students) and determined that the interest of male students in STEM careers is more positive compared to the female students. Another study conducted by Ünlü and Dökme [25] utilized the STEM-CIS instrument to examine a sample of comparable size from various regions of the country. The findings indicated that students' interest in STEM careers varied significantly based on their gender, geographical location, and grade levels. However, no significant differences were observed in relation to their parents' educational status or family income levels.

A pivotal aspect involves identifying the factors that foster interest in STEM careers among high school students who are in the crucial stage of exploring their career interest [26, 27], as several studies focused on this particular period. For instance, Sadler et al. [28] conducted a retrospective cohort study to exemplify how the interests in STEM career of high school students change. The study findings by Robnett and Leaper [26] showed a gender difference in STEM-related career interest in high school and suggested that social identities and self-concepts play a substantial role in shaping the STEM career choices of young individuals. Ketenci et al [28] and Myint and Robnett [29] also reported gender differences choice on STEM career attainment. Kızılay and Yamak [30] employed the Career Interest Scale for STEM Fields [31] as data collection tool and revealed a gender disparity among high school students, in favour of male students.

III. METHODOLOGY

A. Design

The present study employed a descriptive survey model to investigate the STEM Career Interest of secondary school students in Portugal. Data were gathered using the STEM Career Interest Survey (STEM-CIS) [20].

B. Participants

A non-probabilistic (convenience) sampling approach was utilized to select participants from two 12th-grade classes attending the Chemistry subject during the academic year 2022/2023. The initial sample size consisted of 212 students, but after exclusions, the final sample included 190 students, representing 89.6% of the students. In terms of gender distribution, 44.2% (84 students) were male, while 55.8% (106 students) were female, with an average age of 17.2 years.

C. Instruments

The questionnaire, adapted for use in Portuguese, comprised four discipline-specific subscales: Science (S), Technology (T), Engineering (E), and Mathematics (M). Each subscale consisted of 10 items, resulting in a total of 40 questions answered on a 5-point Likert scale, ranging from 'strongly disagree' to 'strongly agree'.

D. Data analysis

The questionnaire results were analysed using Jamovi 2.2.5.0 software. To analyse the questionnaire's psychometric characteristics, an exploratory factor analysis was carried out using minimum residuals extraction. Reliability was examined by calculating *Cronbach's* alpha (α) in the questionnaire and all subscales. To address RQ1 and RQ2, descriptive statistics were examined, and the average score was obtained for each subscale of the questionnaire. The normality assumption of the data was checked using the *Shapiro-Wilk* test. It was found that some subscales did not follow a normal distribution ($p \leq 0.05$), as a result, non-parametric tests (*Friedman* test and pairwise comparisons through *Durbin-Conover* test) were employed to determine differences in students' interests across the STEM fields. Regarding RQ3, to assess the effect of gender on STEM career interest within specific STEM fields, *independent samples t-tests* were used if the assumptions of normality (*Shapiro-Wilk* test) and equal variances (*Levene's test*) were met. Otherwise, the *Mann-Whitney U* test was employed. The effect size was calculated using Cohen's *d* value. The magnitude of the effect size was assessed independently of the d sign and can take on any value. Successively, the *d* values of 0.2, 0.5, and 0.8 are evaluated as representing small, medium, and large effects, respectively [32]. The statistical analyses used a confidence level of 95% ($p < 0.05$).

IV. RESULTS AND DISCUSSION

To assess the levels of STEM career interest among secondary-school students (RQ1), a descriptive analysis was performed. Table I displays the minimum (Min) and maximum scores (Max), along with the mean (M) and standard deviation (SD), obtained by students on the discipline-specific subscales of the STEM-CIS.

TABLE I. DESCRIPTIVE ANALYSIS OF THE SECONDARY-SCHOOL STUDENTS' STEM CAREER INTEREST

						Shapiro-Wilk	
Subscale	***N***	***M***	***SD***	***Min***	***Max***	***W***	***p***
Science	190	3.61	0.704	1.73	5.00	0.983	0.021
Mathematics	190	3.63	0.674	1.64	5.00	0.988	0.123
Technology	190	3.66	0.665	1.67	5.00	0.981	0.011
Engineering	189	3.31	0.810	1.00	5.00	0.976	0.002

The career interest of the secondary-school students was observed to vary across different areas, with technology, mathematics, science, and engineering ranking from the highest to the lowest in terms of preference.

Regarding RQ2, the *Friedman* test showed that the secondary-school students' STEM career interests displayed statistically significant differences in terms of STEM fields ($X^2_{(3)} = 37.3$; $p < 0.001$). To identify the specific STEM fields associated with this observed difference, a Post hoc *Durbin-Conover* test was performed. The results of this analysis are presented in Table II.

TABLE II. RESULTS OF THE PAIRWISE COMPARISONS (DURBIN-CONOVER TEST)

Subscale	***Subscale***	***Statistic***	***p***
Science	Mathematics	0.062	0.950
	Technology	1.471	0.142
	Engineering	4.475	< 0.001*
Mathematics	Technology	1.533	0.126
	Engineering	4.413	< 0.001*
Technology	Engineering	5.947	<0.001*

*p. <0.05

Based on the findings presented in Table II, no significant difference was observed between the career interest in science and the career interest in mathematics and technology among secondary-school students. However, a significant difference was detected in the interest levels of engineering fields compared to mathematics, technology, and science, favouring the latter areas.

In other studies that utilized the STEM-CIS to assess students' career interests across various STEM fields, it was found that interest in engineering careers tended to be lower when compared to mathematics, science, and technology [24, 33].This result is not surprising, as students typically receive limited (or none) education related to engineering in school [24], and a significant number of them are not familiar with careers in this field, resulting in an unclear vision about the field of engineering [34]. Furthermore, negative stereotypes associated with engineers, such as the perception that they are nerds or that they must be geniuses, contribute to this lack of knowledge [24, 33]. Consequently, pre-university students may face challenges in making informed decisions when considering engineering as a potential career path [34].

In order to attract students to STEM careers, such as engineering, there is a need to build better understanding of young people's perceptions of STEM as well as to develop appropriate programs, activities or interventions that will positively influence their perceptions of STEM [35, 36]. Research have demonstrated that effective teaching practices within and beyond the classroom, as well as after-school activities, play a significant role in shaping perceptions of STEM careers [35, 37]. Consequently, it is crucial to prioritize the enhancement of professional development opportunities for teachers, considering their influential role in shaping students' perceptions. Providing teachers with strategies to facilitate student learning of engineering concepts, such as the engineering design process, has the potential to enhance their ability to integrate engineering principles into the classroom, and may positively impact students' interest and engagement in engineering-related fields [34].

To evaluated if the interest in STEM careers among secondary-school students differ in terms of gender (RQ3), *independent sample t* test or *Mann-Whitney U* test were used, and its results are presenting in Table III. The assumptions of normality (*Sharipo-Wilk* test), and equal variances (*Levene's test*) were checked to all subscales. Thus, the science subscale presented normal distribution [$W_{(188)} = 0.987$; $p = 0.068$] and equal variances [$F_{(1,188)} = 0.927$; $p = 0.337$]. Similarly, the mathematics subscale presented a normal distribution [$W_{(188)} = 0.989$; $p = 0.158$] and equal variances [$F_{(1,188)} = 0.126$; $p = 0.723$]. However, the technology subscale violated the assumption of normality [$W_{(188)} = 0.983$; $p =0.023$] and showed homogeneity of variances [$F_{(1,188)} = 0.659$; $p = 0.418$]. Lastly, engineering subscale violated the assumption of normality [$W_{(188)} = 0.972$; $p < 0.001$] and the assumption of equal variances [$F (1,188) = 6.12$; $p = 0.014$].

TABLE III. DESCRIPTIVE ANALYSIS OF THE SECONDARY-SCHOOL STUDENTS' STEM CAREER INTEREST

Subscale	*Gender*	*N*	*M*	*SD*	*df*	*t*	*U*	*p*	*Cohen' s d*
S	F	106	3.72	0.66	188	2.51	----	0.013*	0.37
	M	84	3.47	0.74					
M	F	106	3.64	0.68		0.26	----	0.796	------
	M	84	3.62	0.67					
T	F	10	3.56	0.65		---	3505	0.012*	-0.34
	M	84	3.78	0.67					
E	F	106	3.22	0.72		---	3465	0.012*	0.21[a]
	M	84	3.43	0.89					

Note: M= Mean; SD= Standard Deviation; t = independent sample t test; U= Mann-Whitney; p.= level of significance; *p. <0.05; [a] Rank Biserial correlation.

According to Table III, a statistically significant difference, in terms of gender, was observed in students' career interest across the fields of science [$t_{(188)} = 2.51$; $p = 0.013$], technology [$U_{(188)} = 3505$; $p = 0.012$] and engineering [$U_{(188)} = 3465$; $p = 0.012$]. The effect sizes indicated that the gender effect on career interest in science, technology, and engineering fields was of a small magnitude.

This study revealed that female students had less interest in the careers related to engineering and technology than male students. By other side, female students had more interest in the careers related to science than male students. These findings are consistent with other research studies that have identified a gendered pattern in STEM fields, indicating that females tend to prefer careers in medical/health and biology, while males are more inclined towards engineering and computer sciences [3, 6, 16, 17, 18].

These differences can be attributed to traditional perceptions of gender roles and identities as well as the cultural values sometimes associated with specific professions [26]. Many female students do not know much about the engineering field, and many are thought to be more interested in leading their careers on the way to serve for the society [38]. Concerns about not fitting the stereotypical image of a STEM professional and doubts regarding their own abilities to succeed in STEM fields contribute to women's apprehension [39]. Moreover, numerous female students perceive engineering as "difficult," "boring," and predominantly male-oriented, often associating it solely with construction work [40]. Consequently, these outdated and invalid stereotypes have a detrimental impact on females' interest and attitudes towards STEM fields and careers [41].

Other studies have indicated that female students tend to exhibit lower interest in engineering compared to their male counterparts, potentially due to the lack of sufficient role models who have pursued STEM careers [42]. The decision of a female student to pursue a STEM career can be influenced by the presence of female role models, such as teachers or relatives [25, 41, 42, 43]. According to Dubetz and Wilson [43], secondary school female students who participate in summer camp activities organized by universities and guided by female role models in science and mathematics exhibit a higher level of interest in STEM careers in higher education. Additionally, Ünlü and Dökme [25] stated that individuals who have family members with STEM careers have an increased likelihood of choosing STEM fields.

V. CONCLUSIONS

The main objective of this study was to explore the level of interest in STEM careers among upper secondary students in Portugal, using the STEM Career Interest Survey. However, there are some limitations. The low number of participants is a limitation that may affect the generalisability of the results. Quantitative research often focuses on identifying patterns and relationships but may not capture the nuances and complexities of individuals' experiences or perspectives. Therefore, the study may not have provided a complete understanding of the issues surrounding STEM career choice.

Despite these limitations, the results of the study provided an overview of the interest of Portuguese secondary school students in STEM careers, following educational reforms aimed at strengthening STEM education. The results showed a relatively low interest in engineering careers compared to mathematics, science, and technology among secondary school students. To attract students to STEM careers, especially engineering, it is imperative to develop effective interventions, aligned with ongoing initiatives, aimed at influencing their perceptions of STEM fields.

The results of the study also highlighted a gender gap in students' interest in science, engineering, and technology-related careers. To rectify this situation and bridge the gender gap, it is important to introduce STEM education initiatives within educational institutions and to extend them to other settings. To meet this need, it is therefore essential to prioritise the improvement of professional development opportunities for teachers, given their influential role in shaping students' perceptions.

The identified findings have valuable implications for various stakeholders in the education sector, including education policy makers, curriculum developers and teachers. These findings underline the importance of STEM education in fostering and nurturing students' interest in STEM fields, but Portugal can do more and better. As such, they can serve as an important guide for education policy makers in designing policies that promote and prioritise STEM education. Curriculum developers can use these findings to design and improve STEM curricula, ensuring that they are aligned with students' interests and address the gender gap in STEM career preferences. Finally, teachers can benefit from this knowledge by incorporating engaging STEM activities and promoting female role models to inspire and encourage students, particularly female students, to pursue STEM subjects.

Future research should consider conducting qualitative studies to obtain more detailed results. In addition, researchers could focus on variables other than gender, such as where participants live, what grade they are in, and what level of education their parents have. By examining these additional variables, researchers can explore how different factors influence the decision-making process regarding STEM careers.

REFERENCES

[1] National Research Council [NRC], "Successful K-12 STEM education: identifying effective approaches in science, technology, engineering, and mathematics", The National Academies Press, Washington, USA, 2011.

[2] L. Halim, E. Shahali, and Z. Iksan, "Effect of environmental factors on students' interest in STEM careers: The mediating role of self-efficacy", *Research in Science & Technological Education*, 2021.

[3] OECD, "Education at a glance 2022: OECD indicators", OECD Publishing, Paris, France, 2022.

[4] M. J. Hernández-Serrano, and J. M. Muñoz-Rodríguez, "Interest in STEM disciplines and teaching methodologies. Perception of secondary school students and preservice teachers", *Educar,* vol. 56, no.2, pp. 369-386, 2020.

[5] UNESCO, "Cracking the code: Girls' and women's education in science, technology, engineering and mathematics (STEM)", *UNESCO*, 2017. https://unesdoc.unesco.org/ark:/48223/pf0000253479

[6] D. Card, and A. A. Payne, "High school choices and the gender gap in STEM", *Economic Inquiry,* vol. 59, no. 1, pp. 9–28, 2021.

[7] OIT, "How many women work in STEM", 2020. https://ilostat.ilo.org/how-many-women-work-in-stem/

[8] H. Horta, "STEM education in Portugal: Education, policies and labor market", *Consultant Report. Securing Australia's Future STEM: Country Comparison*, Melbourne, Australia: Australian Council of Learned Academies, 2013. http://acola.org.au/PDF/SAF02Consultants/Consultant%20Report-%20Portugal.pdf.

[9] M. Batista, "Educação STEM em Portugal: iniciativas e desafios para o futuro", In *Policy Brief IE-ULisboa n.º6*, Instituto de Educação - ULisboa, 2023.

[10] Ministério do Planeamento, "PRR – Recuperar Portugal, Construindo o Futuro". Lisboa: Ministério do Planeamento, 2021. https://www.portugal.gov.pt/download-ficheiros/ficheiro.aspx?v=%3D%3DBQAAAB%2BLCAAAAAAABAAzNDQzNgYA62SpeQUAAAA%3D

[11] D. Jeffries, D. D. Curtis, and L. N. Conner, "Student factors influencing STEM subject choice in year 12: A structural equation model using PISA/LSAY data", *International Journal of Science and Mathematics Education,* vol. 18, pp. 441-461, 2020.

[12] D. Ardianto, B. Rubini, and I. D. Pursitasari, "Assessing STEM career interest among secondary students: A Rasch model measurement analysis", *Eurasia Journal of Mathematics, Science and Technology Education,* vol. 19, no. 1, pp. 1-8, 2023.

[13] E. Regan, and J. DeWitt, "Attitudes, Interest and Factors Influencing STEM Enrolment Behaviour: An Overview of Relevant Literature." In *Understanding Student Participation and Choice in Science and Technology Education*, Dordrecht: Springer, ed E. K. Henriksen, J. Dillon, and J. Ryder, 2015, ch. 5, pp. 63–88.

[14] G. Nugent, B. Barker, G. Welch, N. Grandgenett, C. Wu, and C. Nelson, "A Model of Factors Contributing to STEM Learning and Career Orientation", *International Journal of Science Education,* vol. 37, no. 7, pp. 1067-1088, 2015.

[15] E. T. Iskander, P. A. Gore, C. Furse, and A. Bergerson, "Gender differences in expressed interests in engineering-related fields ACT 30-year data analysis identified trends and suggested avenues to reverse trends", *Journal of Career Assessment,* vol.21, no.4, pp. 599-613, 2013.

[16] K. Modi, J. Schoenberg, and K. Salmond, "Generation STEM: what girls say about science, technology, engineering, and math", Girl Scout Research Institute, New York, USA, 2012.

[17] J. Sikora, and A. Pokropek, "Gender segregation of adolescent science career plans in 50 countries", *Science Education,* vol. 96, pp. 234-264, 2012.

[18] E. Wiebe, A. Unfried, and M. Faber, "The relationship of STEM attitudes and career interest", *EURASIA Journal of Mathematics, Science and Technology Education, vol.14*, no.10, 2018.

[19] T. Tyler-Wood, G. Knezek, and R. Christensen, "Instruments for Assessing Interest in STEM Content and Careers", *Journal of Technology and Teacher Education,* vol.18, no. 2, pp. 345-368, 2010.

[20] M. W. Kier, M. R. Blanchard, J. W. Osborne, and J. L. Albert, "The development of the STEM career interest survey (STEM-CIS)", *Research in Science Education,* vol. 44, no. 3, pp. 461-481, 2014.

[21] R. W. Lent, S. Brown, and G. Hackett, "Toward a unifying social cognitive theory of career and academic interest, choice, and performance", *Journal of Vocational Behavior*, vol. 45, no. 1, pp. 79-122. 1994.

[22] Z. K. Ünlü, I. Dökme, and V. Ünlü, "Adaptation of the science, technology, engineering, and mathematics career interest survey (STEM-CIS) into Turkish", *Eurasian Journal of Educational Research,* vol. 16, no. 63, pp. 21-36, 2016.

[23] İ. Dönmez, and Ş, İdin, "Determination of the STEM Career Interests of Middle School Students", *International Journal of Progressive Education,* vol. 16, no. 4, pp. 1–12, 2020.

[24] A. Ergün, "Identification of the interest of Turkish middleschool students in STEM careers: Gender and grade level differences", *Journal of Baltic Science Education,* vol. 18, no. 1, pp. 90–104, 2019.

[25] Z. K. Ünlü, and İ. Dökme, "Multivariate Assessment of Middle School Students' Interest in STEM Career: a Profile from Turkey", *Research in Science Education,* vol. 50, pp. 1217–1231, 2020.

[26] R. D. Robnett, and C. Leaper, "Friendship groups, personal motivation, and gender in relation to high school students' STEM career interest", *Journal of Research on Adolescence,* vol. 23, pp. 652–664, 2013.

[27] P. M. Sadler, G. Sonnert, Z. Hazari, and R. Tai, "Stability and volatility of STEM career interest in high school: A gender study", *Science Education,* vol. 96, pp. 411-427, 2012.

[28] T. Ketenci, A. Leroux, and M. Renken, « Beyond Student Factors: a Study of the Impact on STEM Career Attainment", *Journal for STEM Education Research,* vol. 3, pp. 368–386, 2020.

[29] E.T. Myint, and R.D. Robnett, "Correlates of adolescents' STEM career aspirations: the importance of academic motivation, academic identity, and gender" *European Journal of Psychology of Education*, 2023.

[30] E. Kızılay, and H. Yamak, "Factors affecting high school students' motivation and career interest in STEM fields and their modeling", *Science Insights Education Frontiers,* vol. 16, no. 1, pp. 2409-2433, 2023.

[31] E. Kızılay, H. Yamak, and N. Kavak, "Development of the STEM career ınterest scale for high school students", *European Journal of Educational Sciences,* vol. 7, no. 3, pp. 48-70, 2020.

[32] S. B. Green, and N. J. Salkind, "Using SPSS for Windows and Macintosh: Analyzing and understanding data" , 4th Ed., Prentice Hall, Boston, USA, 2005.

[33] F. Zorlu, and Y. Zorlu, "Comparison of Science Process Skills with STEM Career Interests of Middle School Students", *Universal Journal of Educational Research*, vol. *5, no.*12, pp. 2117-2124, 2017.

[34] S. Compeau, "The calling of an engineer: High school students' perceptions of engineering", M.S. Thesis, Queen's University, Kingston, Ontario, Canada, 2016.

[35] E. H. M. Shahali, L. Halim, M. S. Rasul, K. Osman, and M. A. Zulkifeli, "STEM Learning through Engineering Design: Impact on Middle Secondary Students' Interest towards STEM", *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 13, no. 5, pp. 1189-1211, 2017.

[36] L. E. Mohtar, L. Halim, N. A. Rahman, S. M. Maat, Z. H. Iksan, and K. Osman, "A Model of Interest in STEM Careers among Secondary School Students", *Journal of Baltic Science Education*, vol. 18, no. 3, pp. 404-416, 2019.

[37] S. S. Guzey, M. Harwell, and T. Moore, "Development of an instrument to assess attitudes toward science, technology, engineering, and mathematics (STEM): Attitudes toward STEM", *School Science and Mathematics,* vol. 114, no. 6, pp. 271-279, 2014

[38] L. S. Hirsch, J. D. Carpinelli, H. Kimmel, R. Rockland and J. Bloom, "The differential effects of pre-engineering curricula on middle School Students' attitudes to and knowledge of engineering careers", 2007, 37th Annual Frontiers In Education Conference - Global Engineering: Knowledge Without Borders, Opportunities Without Passports, Milwaukee, WI, USA, 2007, pp. 17-21.

[39] A. Master, and A. N. Meltzoff, "Cultural Stereotypes and Sense of Belonging Contribute to Gender Gaps in STEM", *Grantee Submission* vol. 12, no. 1, pp.152–198, 2020.

[40] F. Gülhan, and F. Sahin, "The effects of science-technology-engineering-math (STEM) integration on 5th grade students' perceptions and attitudes towards these areas", *Journal of Human Sciences*, vol.13, no. 1, pp. 602-620, 2016.

[41] A. Ciftci, M. S. Topcu, and I. Erdogan, "Gender Gap and Career Choices in STEM Education: Turkey Sample", *International Journal of Progressive Education*, vol. 16, no. 3, pp. 53-66, 2020.

[42] T. Chavatzia, "Cracking the code: Girls' and women's education in science, technology, engineering and mathematics (STEM)", Unesco, Paris, France, 2017.

[43] T. Dubetz, and J. A. Wilson, "Girls in engineering, mathematics and science, GEMS: A science outreach program for middleschool female students", *Journal of STEM Education*, vol. 14, no. 3, pp. 41-47, 2013.

ONTOCNE, CHARACTERIZING LEARNING RESOURCES FOR TRAINING COMPUTATIONAL THINKING

1st Cristiana Araújo
ALGORITMI Research Centre/LASI, University of Minho
Braga, Portugal
decristianaaraujo@hotmail.com

2nd Pedro Rangel Henriques
ALGORITMI Research Centre/LASI, University of Minho
Braga, Portugal
prh@di.uminho.pt

3rd João José Cerqueira
Life and Health Sciences Research Institute (ICVS), University of Minho
Braga, Portugal
jcerqueira@med.uminho.pt

***Abstract*—A Computational Thinking (CT) training program proposes a set of instruments to be used in the training, and also a set of recommendations on how to use them. To design such a program it is necessary to have a deep knowledge about the meaning of CT and its targets. Although CT skills are of paramount importance to all (since they bring numerous advantages for problem solving activities), in our context we see them as a pre-requisite for the learning of Computer Programming (CP). In order to design a CT training program supported by a rigorous framework, we decided to build an ontology that goes deeper into the underlying concepts and relates both domains, CT and CP. The outcome, OntoCnE (that stands for *Ontologia para Computac¸a˜o na Escola* in Portuguese), made clear what shall be trained in terms of reasoning to understand programming and being able to use it to solve problems using the computer. Moreover, OntoCnE also provides a clear insight on the concepts to be taught in each scholar year, as well as, on the instruments (hereafter called *Learning Resources*, LR) to be used in each moment for each specific purpose. This paper aims to introduce OntoCnE and demonstrates how to use it to classify LRs aiming to build a repository from where they can be picked up in a clear way. Finally, we demonstrate, through the PathIt resource, how the characterization of a concrete LR is performed in OntoCnE.**

***Index Terms*—Computational Thinking, Ontology, OntoCnE, Learning Resources**

I. INTRODUCTION

Students, in general, demonstrate deficits in various problem-solving skills, lack of motivation, and inadequate study methods. These deficits are even more notorious when students enroll in Computer Programming (CP) courses. Learning CP is difficult and requires problem solving skills, a lot of training, dedication and persistence [1]–[3]. Several researchers claim that, for many students, the problem starts right at the beginning of learning [1], [2], [4]. The problem of teaching-learning programming is serious, not only because of the important concepts that underlie and structure the course, but also because of the feelings of failure, lack of motivation and abandonment that such frustration can produce in the student [1], [5] .

According to the literature, there is a set of factors that can interfere in the process of teaching-learning programming. The origin of difficulties in programming lies in the deficient ability to solve generic problems, which leads students to have difficulties in designing algorithms [1]. The ability to solve problems is very important in the programming task and requires many skills that students usually do not have, namely: understand the problem (they have difficulty interpreting problems) [1], [3], [4], [6]–[10]; decompose the problem (they have difficulty breaking the problem into parts and eliminating unnecessary details) [1], [3], [4], [6]–[10]; relate new with previous knowledge (demonstrate difficulties in establishing analogies with problems that they have already solved before or sometimes apply previous knowledge in a wrong way) [1], [3], [6], [10]; reflect on the problem and the solution (they write the answers without thinking carefully about them and in the case of programming, they do not test the constructed so- lution, or when they do, they do not check the limit cases) [1]– [3], [7], [9]; lack of persistence (give up on problems for which they can not find a quick and simple solution) [1], [3], [9], [10]. In addition, students also have deficits in mathematical knowledge and logical reasoning, including in transforming a textual problem into a mathematical formula that solves it [1]– [3], [9]–[11]. Finally, students also have a reduced capacity for abstraction and therefore have difficulties moving from a concrete world to a more semantic and symbolic reality, formulating or representing a problem in a more abstract way [1], [3], [4], [9], [10].

In addition, the study methods adopted by many students, reading or memorizing formulas, among others, are often not the most suitable for learning programming. In order to do so, different study methodologies, such as deep understanding, reflection and repeated practice/training are necessary [1], [3]. Many CP students are not motivated to study programming, perhaps because programming exercises are far from their expectations or their future reality [1], [3], [10]. The teaching methods used seem to be inadequate for the needs of many students, for several reasons: teachers are generally more concerned with teaching a particular programming language and its syntactic details than with promoting problem solving using a programming language [1], [3], [10]; teaching is not personalized to the needs of each student (it is difficult to provide adequate and personalized feedback and supervision to the needs of each student) [1], [3], [10], [12]; and the teacher's strategies, usually, do not contemplate all students' learning styles [1].

We can conclude that many of the problems related to programming learning have their deep roots in the fact that students who arrive at CP courses do not have the essential skills, that they should have acquired in previous years.

We argue that the solution to the problems presented above is to train Computational Thinking (CT) from an early age. CT training promotes the development of skills such as: pattern recognition, logical reasoning, decomposition, persistence, abstraction, among others. We believe that if all children acquire and train these skills from childhood, they will be able to overcome difficulties in programming courses more easily. In order to rigorously define how to train CT skills to develop competences for learning CP, we built an ontology (OntoCnE) that relates the domains of CT and CP. This ontology also identifies the concepts to be taught in each school year, as well as the Learning Resources (LR) that allow training them. The ontology it is a working tool that will provide the teacher with a rigorous work plan to train CT skills with their students. PathIt (inclusive LR to train people with or without visual impairment, built by our work team) will be used as a case study to illustrate the characterization of an LR in OntoCnE. This paper is organized into 5 sections. Section II presents the definition of CT. In Section III OntoCnE and its structure in layers is discussed: Concepts to train (Layer 1); Training per level of education (Layer 2); and Materials to use (Layer 3). Section IV discusses the case study to show how to use the ontology to characterize a concrete LR, PathIt. Finally,

Section V presents conclusions and perspectives for future work.

II. Training Computational Thinking

Jeannette Wing, was the first to introduce the term Computational Thinking (CT), in 2006. Wing defines CT as being *a method of solving problems, designing systems and understanding human behavior, based on fundamental concepts of computer science*. She argues that CT should be considered a fundamental skill, on par with reading, writing and arithmetic, in order to increase each child's analytical capacity. CT ability is crucial for everyone, not just computer scientists [13].

Researchers describe CT as a problem-solving approach that requires (but is not limited to) the following skills: abstraction (identifying what is important and remove unnecessary details) [14]–[17]; algorithmic thinking (ordering a set of instructions or rules for doing something) [14]–[17]; decomposition (breaking a problem into smaller parts that are easier to understand and solve) [14]–[17]; patterns recognition (identifying similarities or characteristics between problems and solving the problem using solutions previously defined in other problems and based on experiences) [16], [17]; logical reasoning (predict and analyze; explain why something happens) [15]–[17]; and evaluation (ensure that the solution is adequate to solve the problem, checking the limit cases) [14], [16], [17].

These skills are supported and enhanced by abilities or attitudes which are essential dimensions of CT.

These abilities or attitudes include: collaborating (working as a team) [16], [17], persevering (continue and never give up, even when the problem is more complex to solve) [16], [17]; debugging (finding and fixing errors) [17]; tinkering (change and see what happens – cause and effect experiments) [17]; and creating (design and make with creativity) [17].

Training in CT, from an early age, will allow students to develop the problem-solving skills that it contemplates, and which are essential to solve problems in any area. Furthermore, students who intend to learn Computer Programming (CP) would already have the problem solving skills acquired, and they would just need to learn the concepts concerned with computers, programs, and programming languages to be able to solve problems using a computer [18]. It can be said that those trained students would have already acquired the crucial skills to think through the steps needed to solve a problem; and they would just need to acquire technical skills to make the computer work on the problem.

In next section, both domains, CT and CP will be defined and related through an ontology. For that, OntoCnE will be presented as well as its structure in layers.

III. OntoCnE – Ontology for Computing at School

The domains of Computational Thinking (CT) and Computer Programming (CP) are composed of several concepts that are related to each other. Therefore, years ago we decided to create an ontology to clarify and formalize such a relationship. In its genesis, this ontology was built by a multidisciplinary team (Computer Programming Teachers from Higher Education, IT Teachers and other areas Teachers from K-12). Over the years, this ontology has also been validated by several IT Teachers from K-12. Recently, we contrasted this ontology with the *Reference curriculum in technology and computing: from early childhood education to primary education* from Brazil [19] and we intend to contrast it with more curricula from other countries. The ontology components (concepts, relations, and triples) were added incrementally by the Team Members based on their scientific knowledge learned from their graduation studies and 20 to 40 years of teaching Computer Sciences and Software Engineering.

Guarino describes an ontology as an artifact of engineering, consisting of intentional vocabulary related to a certain reality, together with explicit assumptions in the form of first-order logic, representing concepts and relationships between concepts [20]. An Ontology describes a domain of knowledge, identifying: domain *concepts* and *relationships* among concepts. Concepts are characterized by zero, one or more *attributes*. A concrete ontology also includes *Individuals* who are instances of concepts. In addition to concepts and relationships, the ontology is composed of several *triples*. A triple has three elements – *Subject, Predicate, Object* – where *subject* and *object* are concepts or individuals, and *predicate* is a relation.

OntoCnE (Ontology for Computing at School)[1] aims to define two knowledge domains and their interception – Com-

[1]From the Portuguese term *Ontologia para Computação na Escola*.

putational Thinking, and Computer Programming – in order to be able to state with rigor: how to train CT; what to train at each level of education and at which depth; and the material used to train it at the various levels of education [21]. The ontology that defines the CT and CP domains is composed of 3 layers.

OntoCnE is described in the formal language On-toDL+ [22], a DSL specifically designed to facilitate the process of defining and instantiating an ontology. Although not a standard, OntoDL+ compiler generates OWL for OWL for interoperobility purposes. In following sections we will present each of the layers in detail.

A. OntoCnE- Layer 1 – Concepts to train

Layer 1 of OntoCnE gathers a set of concepts that describe the CT and CP domains. In Listing 1, a fragment of the concept list, sorted alphabetically, is displayed. In this fragment and the next ones, we select the most important concepts, relations and triples that best characterize the CT and CP domains.

Listing 1: Concepts that describe the domains of CT and CP (fragment).

```
Concepts{
    Abstraction, Algorithm, Algorithmic_Thinking,
    Attribution, Automaton, Bit, Block, Byte,
    Collaboration, Computational_Thinking,
    Computer, Control_Structure, Creation,
    Data_Structure, Data,  Decomposition, Debug,
    Evaluation, Error, Flowchart,  Input,
    Instruction, Language, Logical_Reasoning,
    Operation, Operator, Operating, Output,
    Reading, Perseverance, Pattern_Recognition,
    Problem, Program, Programming,
    Regular_Expression, Result, Sequence, Test,
    Text_Lang, Tinkering, Variable, Visual_Lang,
    Writing, ...}
```

After defining the concepts, it was necessary to add the relationships that connect concepts to give meaning to the universe of discourse. Listing 2 displays a fragment of relations (sorted alphabetically).

Listing 2: Relations to relate the concepts that describe the CT and CP domains (fragment).

```
Relations{ acts_on, analyze, break, can_be,
    can_have, detect, follows, guide, involves,
    is_composed_of, is_equivalent_to, is_used_in,
    is_executed_by, is_materialized_by,
    is_written_in, manipulate, oblige, produces,
    requires, structure, ...}
```

After concepts and relations, the necessary tuples (Subject=Predicate=>Object) were defined. Listing 3 is a fragment of that OntoCnE component describing three main concepts: `Algorithm`, `Computational Thinking` and `Program`.

Listing 3: Ontology triples that describe Algorithm and Computational Thinking and Program.

```
Triples{
Algorithm =[
    requires => Computational_Thinking;
    is_materialized_by => Program;
    is_composed_of => Block;
    manipulate => Data Structure;
    oblige => Sequence;
    can_have => Control_Structure;
    produces => Result;
    follows => Skeleton ];
Computational_Thinking =[
    involves => Creation, Debug, Collaboration,
    Tinkering;
    requires => Perseverance,
    Decomposition, Abstraction,
    Pattern_Recognition,
    Logical_Reasoning,
    Algorithmic_Thinking, Evaluation ];
Program =[
    is_composed_of => Block;
    is_guided_by => Automaton;
    is_written_in => Language;
    is_executed_by => Computer ];    ... }
```

Reading the triples makes it simpler to see how the concepts relate to each other to form an understandable and meaningful description. From Listing 3 it is possible to infer facts as: an `Algorithm` requires `Computational Thinking` and is materialized by a `Program`. To go into details, Listing 4 provides more information about some of the object concepts in the listing above that are concerned with CT.

Listing 4: Ontology triples that are related CT (fragment).

```
Triples{
Decomposition =[
    acts_on => Problem;
    break => Problem ];
Debug =[
    analyze => Program;
    detect => Error;
    requires => Perseverance  ];
Tinkering =[ involves => Test, Evaluation ];    ...}.
```

Computational Thinking involves Debug, and from Listing 4 it is possible to understand that Debug that analyzes a Program to detect Errors, and requires Perseverance. To learn more about CP, Listing 5 provides more information about some of the object concepts in the listing above that are concerned with CP.

Listing 5: Ontology triples that are related CP (fragment).

```
Triples{
Block =[ is_composed_of => Instruction ];
Instruction =[
    involves => Operation;
    can_be => Attribution, Reading, Writing  ];
Language=[
    has => Syntax, Semantics, Lexicon;
    can_be => Text_Lang, Visual_Lang];
Automaton =[
    is_equivalent_to => Regular_Expression;
    guide => Program ];
Regular Expression =[
    is used in => Pattern Recognition ];  ...}.
```

`Program` is composed of `Block`, and from Listing 5 it is possible to infer that a `Block` is composed of `Instruction` that can be `Attribution`, `Reading`, `Writing`; and involves `Operation`. Similarly `Program` is guided by an `Automaton` that is equivalent to a `Regular Expression` which is used in `Pattern Recognition`.

Figure 1 displays a fragment of Layer 1 of OntoCnE. For the sake of space we will only present the graphical representation of Layer 1 of OntoCnE graph, and just a small part of it. To view in detail the 3 layers of OntoCnE, consult the web platform: https://computationalthinking4all.epl.di.uminho.pt/ontoCnE.html. In next section we will present the construction of Layer 2 of the ontology.

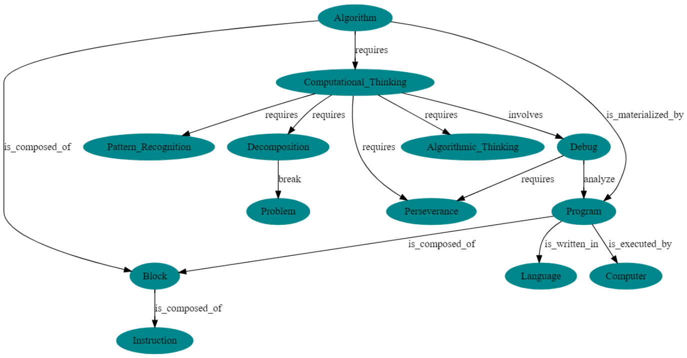


Fig. 1: OntoCnE: Ontology for Computing at School – Layer 1 (fragment)

A. OntoCnE - Layer 2 – Training per level of education

Layer 2 of OntoCnE aims to define what to train at each level of education and its degree of depth. In this layer weadded nine new concepts that represent each year of education, 12 that compose the official cycle of basic education (1st, 2nd and 3rd cycles) in Portugal. In Listing 6 these concepts are presented.

Listing 6: Concepts that represent each year of schooling in Portugal.

```
Concepts{ Year1, Year2, Year3, Year4, Year5, Year6,
    Year7, Year8, Year9 }
```

In this layer, new relationships were also added. These relations are essential to this layer because they reflect the degree of conceptual elaboration on which a teacher must focus focus throughout each educational year. In Listing 7 the twelve relations added in Layer 2 are displayed, sorted by relevance.

```
Relations{ examine, develop, use, introduce, apply,
   reinforce, optimize, identify, create, fix,
   execute, modify ...}
```

We assign a meaning to each relationship in order to rigorously define the extent of strengthening a topic that the instructor will concentrate on over a given year: `examine` – the student analyzes in detail and understands a concept; `develop` – the student acquires/deepens a skill or aptitude; `use` – the student resorts, without formalization or expla- nation, to a concept to be taught later; `introduce` – the student learns a new concept that is formally defined; `apply` – student resorts to the use of a concept, consciously and autonomously, after having been introduced to it in a previous year; `reinforce` – the student remembers and reuses a concept and improves his knowledge by adding complexity; `optimize` – the student analyzes something he has built and improves or perfects the initial solution; `identify` –

the student analyzes something he has built and finds an anomaly or behavior; `create` – the student builds a new object/artifact (eg. Program) from scratch; `fix` – the student analyzes something he has built and solves an anomaly or behavior, which he previously identified; `execute` – the student performs an action (eg. invokes a program to obtain its result); `modify` – the student changes an object to evaluate the consequence of the modification introduced.

These relations allow the linkage of each concept added in Layer 2, with the concepts of Layer 1. Listing 8 shows a snippet of the triples created in Layer 2.

Listing 8: Ontology triples that describe what to train each year – Layer 2.

```
Triples{
Year1 =[
    examine => Problem;
    use => Decomposition, Pattern_Recognition,
    Visual_Lang, Program;
    introduce => Algorithm, Instruction;
    develop => Logical_Reasoning, Abstraction; ...];
Year2 =[
    examine => Problem;
    use => Variable;
    introduce => Decomposition, Pattern_Recognition,
     Visual_Lang, Program;
    execute => Program;
    apply => Algorithm, Instruction;
    identify => Error;
    fix => Error;
    develop => Logical_Reasoning, Collaboration,
    Abstraction; ... ];
Year3 =[
    examine => Problem;
    use => Binary_System;
    introduce => Variable, Writing, Repetition;
    apply => Decomposition, Pattern_Recognition,
    Visual_Lang;
    modify => Program;
    create => Program;
    execute => Program;
    reinforce => Algorithm, Instruction;
    identify => Error;
    fix => Error;
    develop => Logical_Reasoning, Collaboration,
    Abstraction; ... ];   ...}.
```

As we can see, by reading the triples in the Listing 8, the concept Algorithm is formally introduced in Year1, later in Year2 the student already applies the concept (he uses it consciously and uses different algorithms), and in Year3 the student reinforces the concept (he continues to use the concept and always goes deeper). Some concepts such as Abstraction, Problem, Error, occur with the same relationship over the years, yet there is change. Over the years the student skills will evolve, he will be able to abstract and examine more complex Problems and identify and correct Errors with greater complexity. In next section we will present the construction of Layer 3 of OntoCnE.

A. OntoCnE - Layer 3 – Materials to use to train

Layer 3 of OntoCnE aims to define the material used to train the CT in the various education levels. This material is called a Learning Resource (LR). A LR serves to: develop new knowledge; put into practice or reinforce prior knowl edge; encourage the understanding process; contribute to the organization and synthesis of educational content; contribute to the retention of knowledge and attitudes; contribute to logical reasoning, communication and interaction; and contribute to the development of different skills and the acquisition of student values [23].

With that purpose in mind, in this layer we added a new concept – `Learning Resource`– with several attributes that characterize the training artifact. The referred attributes were selected by us, some time ago, to create a model that brings together the main characteristics of an LR, so that teachers can properly select an adequate resource to teach a certain subject to a certain class. Furthermore, in this layer, we also add the individuals (instances of the concept `Learning Resource`). To exemplify a generic individual we will use the term `LR_X`. In Listing 9 this concept, its attributes and an individual are presented.

Listing 9: Concept and Individual to characterize the training material in CT in each teaching level.

```
Concepts{
    Learning_Resource[
       title: string;
       learningObjective: string;
       description: string;
       category: enum;
       type: enum;
       material: string;
       usageRules: string;
       evaluationMethod: string;
       age: (int,int);
       duration: string;
       subjectsInvolved: enum;
       language: string;
       requirements: string;
       author: string ]  ...}

Individuals{ LR_X }
```

As we can see in the Listing 9 `Learning Resource` is characterized by the following attributes: `Title` (LR name); `Learning Objective` (concepts/skills that LR trains); `Description` (text that explains what the LR is and the challenges/tasks it contains); `Category` (eg: game, work- sheet, video, slides, etc.); Type (unplugged, plugged or both); `Material` (needed stuff to use the LR - eg: computer, robot, paper and pencil, etc.); `Usage Rules` (guidelines for using the LR); `Evaluation Method` (LR assessment guidelines); `Age` (age at which it should be used); `Duration` (average time necessary to complete the activity.); `Subjects` Involved (topics that LR addresses - eg: Math, History, English); `Language` (language to be used to perform/com- plete the activity proposed by the LR); `Requirements` (background necessary to execute that activity);

The `Learning Resource` concept will be instantiated with concrete resources that are the real artifacts that will be used to train CT (`LR_X`). In Listing 10 the relations added in Layer 3 are displayed (sorted by relevance).

Listing 10: Relationships to characterize the training material in CT in each education level.

```
Relations{  train, resort  ...}
```

The `train` relationship relates each individual `Learning Resource` to the concepts of Layer 1 that it trains. While `resort` relates the concept `Year(n)`, from Layer 2, with the concept `Learning Resource` and respective individuals from Layer 3. Listing 11 displays a fragment of the Layer 3 triples that aim to: describe the LR and state the concepts it trains in Layer 1 and the teaching levels at which it can be used (Layer 2).

Listing 11: Ontology triples that characterize each LR and at what level of education it can be used.

```
Triples{
    LR_X =[ iof=> Learning_Resource[title='Y',...];
    LR_X =[ train=> Pensamento_Computacional, ... ];
    Ano1 =[ resort=> LR_X, ... ];
...}.
```

In next section we will present the characterization of PathIt game according to OntoCnE.

IV. Case Study: The PathIt LR

OntoCnE is useful to characterize the Learning Resources (LR) in order to be able to select them for a concrete training. To illustrate the characterization of LR in OntoCnE, we will use PathIt (built by our team) as a case study.

PathIt was specifically designed to train Computational Thinking (CT) skills in visually impaired users through tactile and audible components. The LR is composed of: a physical game board and respective pieces (in wood), sequence blocks (hexagonal shape) and repetition blocks (square shape) (both in wood), and a mobile app. The game revolves around the challenge of creating a path between two positions on a game board while navigating through various restrictions and using sequence blocks (see Figure 2). The game-play flow is as follows: players engage in a step-by-step construction process to build the game board, following voice instructions and signaling success through a shake movement. Subsequently, each challenge is presented and players utilize physical sequence blocks equipped with Near Field Communication (NFC) tags to input the desired path sequence into the mobile app. The app offers feedback and guides players through the challenges, which encompass diverse board configurations and progressively heightened difficulty levels. Figure 2 displays two PathIt challenges. On the left we can see a simple challenge whose objective is to go from smile to triangle. On the right we see a more complex challenge whose objective is to go from smile to star, using only 2 direction blocks (hexagonal shape). This challenge contains restrictions on the board and use of repeating blocks (brackets and the number 3 – square blocks). Listing 12 introduces the game PathIt as a concrete LR, while Listing 13 presents the skills trained with it and identifies Year 3 as appropriate level for its use.

Listing 12: Instantiating LR with individual PathIt.

```
Individuals{ PathIt }

Triples{
    PathIt =[ iof => Learning_Resource[
```

Fig. 2: PathIt – Examples of challenges

```
    title = 'PathIt',
    learningObjective= 'PathIt aims train
  algorithmic thinking...',
    description = 'PathIt is a LR for visually
  impaired users...',
    category = game,
    type = both,
    material='board and wood piecies, phone+App',
    usageRules = 'see manual annex',
    evaluationMethod = 'conclude each activity
  with success',
    age = (9,100),
    duration = '45 minutes',
    subjectsInvolved = None,
    language = 'Portuguese',
    requirements = 'None',
    author = 'Angelica Cunha' ];   ...}
```

Listing 13: Triples that characterize PathIt as a LR for Year 3.

```
Triples{
    Year3 =[ resort=> PathIt ];
    PathIt =[
      train=> Abstraction, Algorithmic_Thinking,
              Pattern Recognition, Logical Reasoning
              Persevering, Debugging, Tinkering,
              Instruction, Sequence,
              Control_Structure, Repetition,
              Program, Error ];     ...}.
```

The formal description presented in the listings above allows for the storage of PathIt in our LR repository called LaRaCiTa[2](for details see: [24]), a component of CT4ALL platform.

V. Conclusion

Students of Computer Programming (CP) courses have many difficulties in learning to program, because, according to the literature, they have deficits in problem solving abilities. We believe that training in Computational Thinking (CT) since childhood can help to overcome these deficits. To design a CT training program we built OntoCnE which defines two knowledge domains (CT and CP) and their interception. The ontology is not the solution to the difficulties that students have in learning CP, it is a working tool that will provide the teacher with a standardized instrument to conceptualize and train CT skills with its students. OntoCnE allows for a rigorous definition of: how to train CT; what to train at each level of education and at which depth; and the material used to train it at the various levels of education. To illustrate how a Learning Resource (LR) is described using in OntoCnE we presented PathIt. After the characterization according to OntoCnE, PathIt is ready to be stored in LaRaCiTa. LaRaCiTa was built following OntoCnE and its layered structure for storing categorized LRs. This platform construction methodology allows us to ensure that a teacher selects a resource that is suitable for a given level of education and trains the skills he wants.

As future work, we intend to finish the remaining years of Layer 2 and instantiate Layer 3 with more concrete LR. Furthermore, it is necessary to design and conduct experiments to apply OntoCnE in a real context.

[2]Accessible in: https://computationalthinking4all.epl.di.uminho.pt/laracita/

Acknowledgment

This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020. The Ph.D. work of Cristiana Araújo is supported by FCT – Fundação para a Ciência e Tecnologia, Research Grant, with reference 2020.09845.BD.

References

[1] A. Gomes and A. J. Mendes, "Learning to program - difficulties and solutions," in *Proceedings of the International Conference on Engineering Education (ICEE-2007)*, ser. ICEE-2007, 2007, pp. 283–287.

[2] K. Adu-Manu, J. Kingsley, and P. Owusu, "Causes of failure of students in computer programming courses: The teacher-learner perspective," *International Journal of Computer Applications*, vol. 77, no. 12, pp. 27–32, 2013.

[3] R. P. Medeiros, G. L. Ramalho, and T. P. Falcão, "A systematic literature review on teaching and learning introductory programming in higher education," *IEEE Transactions on Education*, vol. 62, no. 2, pp. 77–90, 2019.

[4] M. Piteira and C. Costa, "Learning computer programming: Study of difficulties in learning programming," in *Proceedings of the 2013 International Conference on Information Systems and Design of Communication*, ser. ISDOC '13. New York, NY, USA: Association for Computing Machinery, 2013, p. 75–80.

[5] J. Figueiredo and F. J. García-Penalvo, "Building skills in introductory programming," in *Proceedings of the Sixth International Conference on Technological Ecosystems for Enhancing Multiculturality*, ser. TEEM'18. Association for Computing Machinery, 2018, p. 46–50.

[6] Y. Qian and J. Lehman, "Students' misconceptions and other difficulties in introductory programming: A literature review," *ACM Trans. Comput. Educ.*, vol. 18, no. 1, 2017. [Online]. Available: https://doi.org/10.1145/3077618

[7] R. Juárez-Ramírez, C. X. Navarro, V. Tapia-Ibarra, R. Macías-Olvera, and C. Guerra-García, "What is programming? putting all together - a set of skills required," in *2018 6th International Conference in Software Engineering Research and Innovation (CONISOFT)*. IEEE Xplore, 2018, pp. 11–20.

[8] P. C. Tavares, "O impacto da animação e da avaliação automática na motivação para o ensino da programação," Ph.D. dissertation, Universidade do Minho, 2018.

[9] A. A. Lawan, A. S. Abdi, A. A. Abuhassan, and M. S. Khalid, "What is difficult in learning programming language based on problem-solving skills?" in *yearInternational Conference on Advanced Science and Engineering (ICOASE)*, 2019, pp. 18–22.

[10] C. S. Cheah, "Factors contributing to the difficulties in teaching and learning of computer programming: A literature review," *Contemporary Educational Technology*, vol. 12, no. 2, 2020.

[11] Y. Bosse, D. F. Redmiles, and M. Gerosa, "Connections and influences among topics of learning how to program," in *2019 IEEE Frontiers in Education Conference (FIE)*. IEEE, 2019, pp. 1–8.

[12] Y. Bosse, D. Redmiles, and M. A. Gerosa, "Pedagogical content for professors of introductory programming courses," in *Proceedings of the 2019 ACM Conference on Innovation and Technology in Computer Science Education*, ser. ITiCSE '19. Association for Computing Machinery, 2019, p. 429–435.

[13] J. M. Wing, "Computational thinking," *Commun. ACM*, vol. 49, no. 3, p. 33–35, mar 2006.

[14] C. Selby and J. Woollard, "Computational thinking: the developing definition," 2013. [Online]. Available: https://eprints.soton.ac.uk/356481/

[15] A. Yadav, C. Mayfield, N. Zhou, S. Hambrusch, and J. T. Korb, "Computational thinking in elementary and secondary teacher education," *ACM Trans. Comput. Educ.*, vol. 14, no. 1, mar 2014.

[16] ISTE and CSTA, "Operational Definition of Computational Thinking for K–12 Education," 2011, accessed: 2021-11- 07.

[17] Barefoot, "Computational Thinking Concepts and Approaches," 2021, accessed: 2021-11-07.

[18] F. J. Garc´ıa-Pen˜alvo and A. J. Mendes, "Exploring the computational thinking effects in pre-university education," *Computers in Human Behavior*, vol. 80, pp. 407–411, 2018.

[19] A. L. A. Raabe, C. P. Brackmann, and F. R. Campos, "Currículo de referência em tecnologia e computação: da educação infantil ao ensino fundamental," Centro de Inovac¸a˜o para a Educac¸a˜o Brasileira (CIEB), Sa˜o Paulo, Tech. Rep., 2018, accessed: 2023-05-07.

[20] N. Guarino, "Understanding, building and using ontologies," *International journal of human-computer studies*, vol. 46, no. 2-3, pp. 293–310, 1997.

[21] C. Araújo, L. Lima, and P. R. Henriques, "An Ontology based approach to teach Computational Thinking," in *21st International Symposium on Computers in Education (SIIE)*, C. G. Marques, I. Pereira, and D. Pe´rez, Eds. IEEE Xplore, 11 2019, pp. 1–6.

[22] A. C. Dias, "ONTODL+: an ontology description language and its compiler," Master's thesis, Universidade do Minho, 2021.

[23] R. Busljeta, "Effective use of teaching and learning resources," vol. 5, no. 2, pp. 55–70, 2013.

[24] C. Araújo, P. R. Henriques, and J. J. Cerqueira, "Training Computational Thinking to leverage Citizens of Next Generation," A´. Rocha, H. Adeli, G. Dzemyda, and S. Costanzo, Eds. Cham: Springer International Publishing, 2023.

IN HEAVEN AS ON EARTH: THE PERFORMANCE OF STUDENTS IS AS GOOD AS IT IS THE DIGRAPH THAT DESCRIBES THEIR BEHAVIOR

L. Castillo
Dept. Computer Science and AI
University of Granada
Spain
L.Castillo@decsai.ugr.es

F. Sánchez-Carrascosa
Acceptare Psicología
Spain
fsc.psicologa@gmail.com

M. Ruiz-Mart´ınez
University of Granada
Spain
e.maribelruizmar@go.ugr.es

J. Fdez-Olivares
Dept. Computer Science and AI
University of Granada
Spain
Faro@decsai.ugr.es

***Abstract*—Detecting groups struggling to overcome their laboratory assignments is paramount for the teacher to assist them, the earliest, the better. Discovering the behavior of students with process mining techniques has proven to be very useful, but commonly associated to students performance indicators. This study proves that student's performance indicators might be very helpful, but as much as it is their behavior, strictly from a topological point of view. In this case, using process mining techniques to extract their behavior from a virtual laboratory and using supervised machine learning techniques to identify "bad topological graphs" also provides enough evidence to foresee these groups at risk**

***Index Terms*—Learning analytics, process mining, student success**

1, 2, (3), (3), (3), 2, 4, (3), (5), 2, (5), 6, 2, 6, 4, 6, (7)

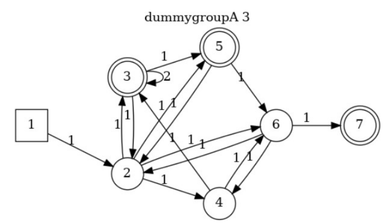


Fig. 1. A basic behavior repeating 7 steps, three of which, between parentheses, have a reward

I. INTRODUCTION

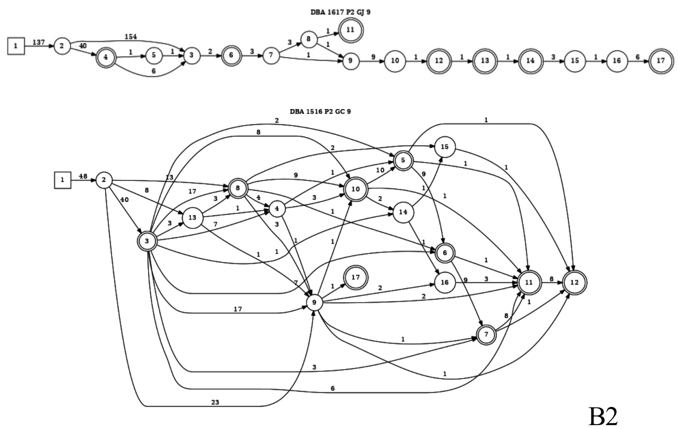
Process Mining to Education is like the X-Rays to Medicine: they make visible the invisible, for the sake of a much accurate situational awareness and for planning further interventions. But to which extent adhering to a graph mined from event logs is relevant instead of, saying, an equivalent tabular rep- resentation? This study was conceived under this perspective and it analyzes student's behavior not as in the classical way of producing timed temporal constraints or performance or any semantic associated to their performance or grades. Instead, this paper analyzes right the pure, naked topology of the behavior and provides sound evidences that these topologies are, how not, also correlated to performance. In particular, to the detection of low-profile groups of students.

Let us suppose that one person needs to complete an activity with seven different steps, numbered from 1 to 7, of which steps number 3, 5 and 7 have a reward. This person could try these steps, and repeat them as many times as he/she considers convenient so as to get all the rewards, keeping a record of his/her activity. Figure 1 shows an example of such behavior. This behavior could have been well represented with the (cyclic) directed, weighted graph in the same figure where the nodes represent the steps given and the edges are weighted with the frequency detected in the record, so the number of times that a step is executed is given by the sum of the weights of its incoming edges. We will name it the in-degree factor.

This linear record of activities is exactly how laboratory assignments are stored in LARVA [1], [2], a virtual laboratory 2[3] designed with one single purpose: enable student to achieve their highest success. In order to do that, LARVA keeps a full record of the activity of students, so their evaluation is based not only on the goals achieved but also on their progress. It relies on a multimodal-feedback system [1] in order to keep students informed about their progress, in real time, thanks to Telegram chat messages directly to their cell phones. The sooner they receive the feedback about their activity and the richer this feedback could be, the higher the self-regulation and the efficacy of the learning experience will be [4].

Revealing this behavior might also be useful to the teacher in order to detect, at the earliest, possible difficulties of the students to complete their assignments and allow a targeted intervention of the teacher. But how to detect these deviations of the expected performance and how early they could be detected? Furthermore, would it be possible to ignore any details about the usual progress indicators associated to per- formance, like timing of successes and failures, perseverance, etc, not to rely too much on "classic efficiency", and focus only on the topological features of the behavior of students? For starters, Figure 2 shows two extreme behaviors. At the top, after 372 sessions, most of them burnt in the 3-4 preliminary steps, ends up with very few sessio ns a t the las t problems, a sort of autopilot, and it solves 7 out of 9 problems. At the bottom, after 297 sessions (might be considered as a lower effort?) it shows a quite thorough exploration of the alternatives and ends up with 9 out of 9 problems solved. This

B1



B2

Fig. 2. Two different **real** behaviors facing the same laboratory assignments. Above, B1, a behavior with 372 work sessions and below, B2, a behavior with 297 sessions

paper successfully answers all these questions from a sound, evidence-based analysis of the records of the last seven years of this virtual laboratory. Next sections are devoted to discuss similar works in the literature, to introduce the scenario and the main hypothesis and then, to draw the main conclusions after a thorough analysis of the data recorded. All of the datasets mentioned in this paper and all the software artifacts, completely written in R, are open and available in GitHub[1]

II. Related work

As said before, the use of Process Mining technique is the receiving a huge amount of interest and there are gigantic amounts of paper and related work that could be referenced, specially when teachers set up virtual laboratories [5] or online services like Coursera [6]. We invite the reader to have a look at some excellent reviews of PM in the educational context like [7] or even better, in [8] where authors also put the emphasis on the analysis of graphs, as the underlying structureal of the behavior. The same authors in [9] also point to a very the highest milestone interesting issue and very related to this paper: how to use PM techniques to detect those that need most the help of the teacher, just by observing the pattern of interaction of students with the LMS (Learning Management System). This relation of the student with the available resources, usually on-line, is also explored in [6] in which the use of PM is not really discovery, but compliance, to detect if the students behave as they are expected to do or in the way they use the available resources [10] . In [11] authors analyze the potential of the feedback that PM could give to students, much in the line of [4] to foster the self-regulation of students. In all of them the main metrics used to guide the study are the ”classical ones” related to resources, people or learning material under a quantitative approach to score the behavior of students. This paper takes a different approach and tries to analyze purely the topology of the directed graph that describe their behavior

[1]https://github.com/Anatoli-Grishenko/ProcessMiningDBA2015-2020

I. Setting the scenario

This study has been carried out within a 4th grader compulsory subject in Software Engineering at the University of Granada and it has been implemented as a virtual laboratory [3]. It follows the typical structure of the Personalized System of Instruction [4] where the progress of students is continually monitored thanks to a system of milestones and continuous achievements, providing as much feedback and soon as it is possible. Hence, During the course, students are arranged in groups (4-5 members each) and every group must solve a number of assignments, or problems.

$$P = \{p_i\}, n = |P|$$

Usually the number of problems is $n = 9$ and they might be seen as a set of missions to be carried out in similar scenarios. Each problem has been carefully crafted by the teacher so they require a increasing level of difficulty by the students in such a way that the strategy to solve p_i might not be good enough to solve p_{i+1} but the strategy to solve p_{i+1} should also be valid in p_i. These problems are open during a certain period of time, during which students may open the problems as many times as they need either to try to solve the problem, to improve their solutions in these problems or to test new strategies. In addition to this, each problem p_i has been designed as a sequence of 5 consecutive milestones, also in increasing level of difficulty:

$$p_i = \{p^1_i, p^2_i, p^3_i, p^4_i, p^5_i\}$$

being p^1_i the event of just opening the problem i and p5, achievement of a valid solution o *pi*. These milestones must be reached progressively by students, so it ends all up by pushing the students a little forward in their capabilities [4]. Hence, as students progress in the laboratory, they leave a trail of their achievements, which will be called the *Behavior*, B^g, of a certain group g, and it is composed of a sequence of sessions. Each *session* in the virtual lab $^s p^k_i$ is labeled as the highest milestone k achieved in each problem *pi*, and a sequential natural number s which is a record of the current system time. Additionally, a mark A is used to signal the beginning of the laboratory period.

$$B^g = \{^0A\} \cup \{^s p^k_i\}$$

For example, in a scenario with three problems, the sequence shown in Figure 3 might be a feasible behavior B, it was already introduced in Section I, and now it is explained under a new perspective.

”Students have connected 16 times to the virtual lab. The first session just opened problem p_1 with no further success, but session 2 completely solves p_1. Students implement new strategies and solve p_1 two more times. Though they introduce a new change that almost solve p_1, it ends up failing, and

Year	Y2015	Y2016	Y2017	Y2018	Y2019	Y2020	Y2021
Groups	9	9	7	11	12	13	16
Size	12088	12525	9088	5705	14475	21188	11961
Sessions	4489	4538	3661	2811	5156	3904	6113
N. days	32	23	29	17	27	16	38

TABLE I

SIZE OF THE RECORD R, SHOWING A TOTAL OF 7 YEARS RECORDED, 77 GROUPS AND 30672 WORK SESSIONS IN THE VIRTUAL LABORATORY

leave p_2 right in the middle. Then, after some changes, they solve again p_1 in session 7 and p_2 in session 8. They changed something but failed in p_1 and end up succeeding in p_3 right at the end"

$$^{0}A \rightarrow {}^{1}p_1^1 \rightarrow {}^{2}p_1^5 \rightarrow {}^{3}p_1^5 \rightarrow {}^{4}p_1^5 \rightarrow {}^{5}p_1^3 \rightarrow {}^{6}p_2^3 \rightarrow {}^{7}p_1^5 \rightarrow$$

$$\rightarrow {}^{8}p_2^5 \rightarrow {}^{9}p_1^1 \rightarrow {}^{10}p_2^5 \rightarrow {}^{11}p_3^4 \rightarrow {}^{12}p_1^3 \rightarrow {}^{13}p_3^2 \rightarrow {}^{14}p_2^4 \rightarrow {}^{15}p_3^2 \rightarrow {}^{16}p_3^5$$

Fig. 3. The behavior of a fictitious group with 16 working sessions in the virtual lab

Table I shows some descriptive information on the data recorded every year about the behavior of 77 groups (nearly 400 students). Next, the challenge is how to extract a graph like those shown in Section I and how to use them to detect, as early as possible, groups with difficulties to progress.

II. EXTRACTING THE STRUCTURE OF THE BEHAVIOUR BY PROCESS MINING TECHNIQUES

As said before, any possible evaluation of the students based merely on the goals achieved is just a static vision, without much clues about the dynamics that led them to that point, we do not know very well how students have arrived there and this information is the key to identify struggling groups which could need the help of the teacher. Theref sequences of correlated events from the original dataset.

A. FuzzyMiner (Disco)

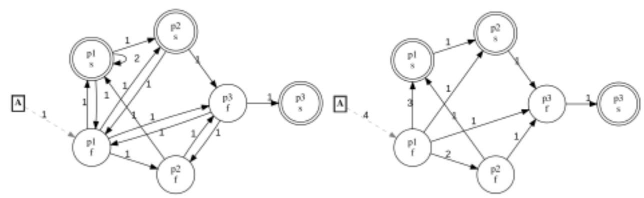
Fuzzy miner [13] is a very flexible, and sound, process mining algorithm which is behind the very well known Disco process mining suite [14]. In a typical process mined with Disco, each activity in the process is labeled as in Figure 3, and includes the frequencies of both activities and transitions between activities. Hence, the frequency of every activity represents the number of times that this activity appear in B^g. The frequency of each transition between activity x and y represents the number of times that activity x appears immediately before activity y in B^g.

Although Disco is very successful and can be customized with many different metrics and interpretations of the source dataset, it does not completely fits our requirements to unveil the structure of the behavior and therefore, the process miner *GraphMiner* was developed in R, mostly based on the main structure of FuzzyMiner [13] with some minor additions.

B. GraphMiner

In order to give a minimal order structure to the behavior Bg, we assume that the following is true: the outcome of session i mostly depends on what happened in session i − 1 or, at the most, in any of its closely preceding sessions. If we accept this assumption, then Bg has a partial order structure where every session appears connected from the previous one.

In addition to this, we could label these relations with a natural number meaning the number of times this relation has been found in Bg. This leads to the chart depicted in Figure 4 (top-left), a fully connected graph that describes the path followed by students with a clear sense of the transitions from one state to another. This graph also fulfills the in-degree factor mentioned at the beginning: the sum of the incoming edges to a node matches the number of times the node appears in the record. However, since this study focuses on success and failure, we are going to collapse this graph. To simplify things, from now on, we will only distinguish two types of sessions: those which fail, that is, those which reach milestones 1-4, and those that succeed, that is, those which reach the final milestone 5. We will distinguish them as ${}^{s}p_i^f$, for failed sessions, and ${}^{s}p_i^s$,for successful sessions, like in Figure 4 (topright).



$$\mathcal{A}^g = \left(\begin{array}{c|ccccccc} & A & p_1^f & p_1^s & p_2^f & p_2^s & p_3^f & p_3^s \\ \hline A & \mathbf{0} & 4 & 0 & 0 & 0 & 0 & 0 \\ p_1^f & 0 & \mathbf{0} & 3 & 2 & 1 & 1 & 0 \\ p_1^s & 0 & 0 & \mathbf{0} & 0 & 1 & 0 & 0 \\ p_2^f & 0 & 0 & 1 & \mathbf{0} & 0 & 1 & 0 \\ p_2^s & 0 & 0 & 0 & 0 & \mathbf{0} & 1 & 0 \\ p_3^f & 0 & 0 & 0 & 0 & 0 & \mathbf{0} & 1 \\ p_3^s & 0 & 0 & 0 & 0 & 0 & 0 & \mathbf{0} \end{array}\right)$$

Fig. 4. Above, left. A collapsed, directed-cyclic graph which captures the precedence relations among the sessions in Figure 3 (16 sessions) obtained by collapsing the vertices from the graph in Figure 4. Doubled-circled nodes represent successful sessions. Above right, the same graph but removing cycles and keeping the in-degree of every vertex the same. Below, the weighted adjacency matrix of the second graph

This perspective, allows us to see B^g as a Directed Graph $G^g = (V^g, E^g)$ which captures the dynamics of a group while they are struggling to solve the different problems they have been given. Therefore, the set of events (sessions) that students go through is the set of vertices of the graph

$$V^g = \{{}^{0}A\} \cup \{{}^{s}p_i^k \in B^g\}$$

and every pair of consecutive sessions is considered as an edge of the graph

$$E^g = \{< x, y >, x = {}^{s}p_i^k, y = {}^{t}p_{r\ j}^{\ l}, t = s + 1, x, y \in B^g\}$$

which, indeed, can be represented as its weighted adjacency matrix and that allows us to represent the in-degree invariant.

C. The characteristic matrix of a group

This graph is still a graph with loops, and since we are interested in the most essential representation of the behavior of students, we also remove those cycles by removing the minimal amount of edges and preserving the in-degree invariant obtaining the essential graph in Figure 4 (bottom) which also shows its distance matrix, which we name the characteristic matrix of the group g, A^g. This characteristic matrix is a minimal representation of B^g and from it, many other features might be extracted, being the most important one, a measure of the inherent complexity of B^g. Therefore, $A^g[x, y] = d > 0$ would mean that x precedes y d times in B^g. The higher d, the higher the influence of x over y in terms of the behavior encoded in A^g. For the sake of simplicity, besides the use of integer values to get a row or column, their names could also be used.

$$A[2, 3] = A[p^f, p^f] = 2$$

Hence Ag contains what could have been the experience of solving all problems, a sort of footprint, that encodes the relation between failure and success and the strength of these relations. It is worth saying that in the whole record of Table I all these matrices are different to each other. Two other matrices will also be used which derive from this one. First it is the characteristic adjacency matrix A''[r, c] which is 1 only when A[r, c] > 0. Second is the minimal distance matrix, which has been obtained by applying Dijkstra's shortest path, so that Aˆ[r, c] contains a sort of minimal path length between both nodes in the graph in terms of the number of sessions. Therefore, these structures are an ideal starting point from which decode information about this experience, in particular, to validate whether this structure might be related to the success or not of each group. That is, would a poor behavior of students produce a poorly structured graph? And vice-versa, would standard quality and entropy measures purely defined on graphs, point to struggling groups?, and the answer, in heavens as on earth, happens to be: yes.

D. General-purpose complexity measures of the characteristic matrix

This section just collects several of-the-shelf complexity measures [15] applied to directed weighted acyclic graphs $G = (V, E)$ via their weighted adjacency matrices

$$A_{vxv}, v = |V| = 2n + 1$$

All of them try to measure how complex is a graph in terms of how densely it is connected between vertices under different perspectives

1. Density

It is the ratio between the number of edges of the graph $|E|$ and the maximum allowed number of edges $v(v - 1)$

$$De(\mathcal{A}) = \frac{|E^{\mathcal{A}}|}{v^{\mathcal{A}}(v^{\mathcal{A}} - 1)}$$

2. Average Degree

The degree of a node is the number of both incoming and outgoing edges, or in the case of weighted graphs, the sum of the incoming and outgoing weights. Then, in directed graphs, it is known that

$$Dm(\mathcal{A}) = \frac{|E^{\mathcal{A}}|}{v^{\mathcal{A}}}$$

3. Characteristic path length r

It is the average number of edges, not their weights, between any pair of nodes, in average. We could apply any shortest path algorithm like Dijkstras [15] to the adjacency matrix A ′ to propagate frequencies and get a closure of the original matrix ˆA′ . This gives an idea of the average depth of the graph, not in the number of sessions, but as the number of edges:

$$Le(\mathcal{A}) = \frac{1}{|E^{\hat{\mathcal{A}}'}|} \sum_r \sum_c \hat{\mathcal{A}}'[r, c]$$

4. Diameter of the graph

It just tries to measure the number of edges between the most distant nodes of the graph.

$$Di(\mathcal{A}) = max(\hat{\mathcal{A}}'[r, c])$$

5. Connectedness

In this case, the clustering coefficient has been chosen [15]. It measures how dense are the subgraphs around the nodes of a certain edge, that is, a measure of local density. Any node i in the graph has a neighborhood, that is, the subset of nodes immediately connected to or from it

$$k_i = \{v_j \in V \ / \ e_{ij} \in E \vee e_{ji} \in E\}$$

then the local clustering coefficient measures the number of existing edges in the neighborhood e_i with respect to the maximum allowed number of edges in this vicinity $|k_i| * (|k_i| - 1)$

$$Cl(\mathcal{A}) = \frac{e_i}{|k_i| * (|k_i| - 1)}$$

6. Betweenness $Be(A)$

It is very well known in social networks and it identifies which of the problems has received more attention and influence than others. It is already implemented in R.

7. Dag

It the average of the length of all different paths are from thee root node to each of the end points of the graph. It tries to measure how "messy" a graph is.

8. WDag

It is based on Dag but instead of measuring the number of steps it collects their weights.

9. St

It is the Laplacian factor of the characteristic matrix. This factor is well known to give the number of spanning trees contained in the Graph, which is also a very common measure of the entropy of a graph.

10. Weight of behavior

It detects how much effort students have devoted to their laboratory assignments in terms of the whole number of sessions open in the server$_k$

$$We(\mathcal{A}) = \sum_r \sum_c \mathcal{A}[r, c]$$

11. Efficacy

It detects how many problems have been solved, just by counting how many nodes p_k^s are present in the graphThese are general metrics that we are going to use to classify the groups of students. Please note that they are defined on weighted directed graphs. They do not take into account absolutely anything related to the performance of students, timing of their progress except functions We (number of sessions) and Ef (number of solved problems) which are extracted solely from characteristic matrix A.

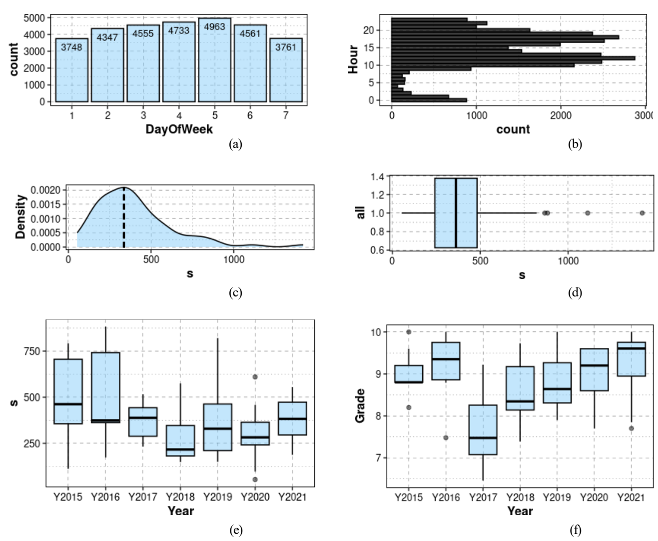


Fig. 5. The effort and dedication of students. (a) Total number of sessions per day of week. (b) Total number of sessions per hour of day. (c) Density function of the number of sessions. (d) Distribution in quartiles of the number of sessions and identificatio´n of outliers (e) Number of sessions each year (f) grades obtained by students each year, out of 10 max points

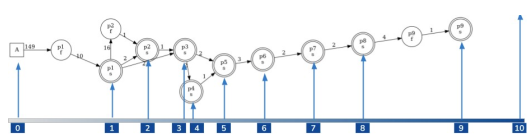


Fig. 6. Stratification of the dataset into 10 consecutive episodes. One for the achievement of each of the 9 problems, plus a final episode until the end of the assignment

III. A FIRST GLIMPSE AT THE DATASET

Figure 5 shows several indicators of the effort of students in the virtual laboratory as far as it is related to the number sessions, s, they connect to the server . The top two charts (a & b) show how the virtual laboratory is at full use all the days and at all times of the day. The chart (c), shows the density function of the recorded number of sessions in the virtual server, which can be considered quite normal, given the short number of groups (77). The vertical dashed line marks the most likely value (336 sessions) which is quite an effort, since they are referred to a short period of time (see Table I). It may be seen a long right tail, due to several outliers, also shown in chart (d) and which will be removed.

The bottom of Figure 5 shows the distribution of the number of sessions over the the years (e) after removing the outliers. These variations over the years might be considered as normal for it is shown by ANOVA ($p = 0.063, 95\%$) and Kruskall-Wallis ($p = 0.05745, 95\%$). A further TukeyHSD test shows that the confidence level of the averages of the number of sessions per year and they might be considered acceptable. Therefore, we could assume that although the number of sessions is different from one year to another, they may be considered random variations since there are not evidences to believe the contrary. The main goal of this approach is trying to identify the students who struggle to pass the laboratory because they, and not the mainstream students, require most of the attention of the teacher to be able to achieve a 100% of success. But who are they? In principle we are going to focus on the students with the lowest quartile of grade, i.e., those whose grade is below, at least, the 75% of other grades (see Figure 7.top). However, given the dynamics of grades each year (Figure 5), one may see that this first quartile might not be very precise. Instead, KMeans function in R was used to divide the range of grades into 5 intervals with an accuracy of 95% in the interdependencies and intradependencies of the 5 clusters. In the KMeans partition, there are two groups whose grades are all strictly below 8. We are going to focus on these lower groups, which will be named ”LOW” and the other groups ”GOOD”.

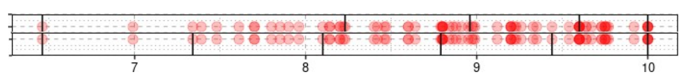


Fig. 7. The frequency of appearance of the grades obtained by each of the 77 groups. The darker the dot, the higher the frequency of that grade. Above, the partition in quartiles. Below, a more precise the partition obtained by KMeans (betweenss/totss= 0.949)

This dataset could be processed as one single cluster of data and we will have only the vision at the end of the assignment period, which might be informative, but not useful for an early intervention. In order to prepare the dataset to be useful at the earliest, it is going to be stratified by levels where each level $i \in [3, 9]$ is marked by the first time the problem (or assignment) i has been solved (Figure 6). Therefore, reaching level 9 means that all assignments are done.

A. Normal behavior of metrics

When dealing with sets of metrics in statistical analysis, it is always a relief having functions with normal distributions and this is quite acceptably the case, as shown in Figure 8. It shows that except Be which has a discrete range (the index of a problem), all of the remaining metrics could be acceptably be considered as normal, given the limited number of groups. On the other hand, given the exponential behavior of some of them, specially those of spectral nature, (Le, Dag, $WDag$ and St) they have been reduced with a general logarithm to obtain equivalent scales in all of the metrics. So, we have a very trustable dataset, enforced with the evidence that there are no biases over the years. We also have a preliminary sound and meaningful partition of grades to be identified, and a brand new set of general-purpose, bell-shaped functions to identify these partitions What else could be wrong?

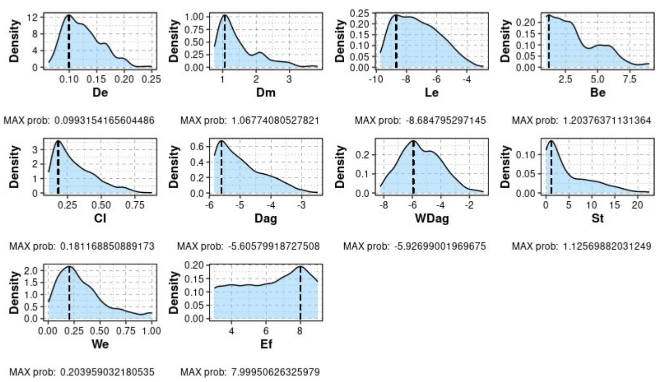


Fig. 8. Density functions of the topological metrics used in the study. The dashed line marks the maximum probability value

Prediction / **Reference**: GOOD: 186 (GOOD), 3 (LOW); LOW: 0 (GOOD), 33 (LOW)	`Rule 4/11: (9.8, lift 2.2)`
	`We > 0.1217391`
	`Le <= -6.944314`
	`St <= 2.079442`
	`-> class LOW [0.916]`

`Accuracy : 0.9865`
`95% CI : (0.961, 0.9972)`
`No Inform. Rate : 0.8378`
`P-Value : 1.24e-13`
	`Rule 4/13: (7.4/0.7, lift 1.9) Dm > 1.933333`
	`Be <= 4`
	`-> class LOW [0.814]`

Fig. 9. Left. Learning to identify ” LOW” groups, that is, those with a score slightly under a grade 8 out of 10. Right. Some of the classification rules

IV. TRAINING C5.0 TO IDENTIFY THE GROUPS IN NEED

Now it is time to learn to identify these subsets of students and, in order to do that, we are going to use Quinlan ‘s C5.0 classification algorithm [16], with decision trees or rules, by using as input variables, the graph-theoretic measures and as the output categories, a single partition into ” LOW ” students, who are supposed to require more effort to overcome the laboratory. Since there are very little records (77 at every level) and the classification problem is going to be a tough one, and in order to increase the evidences required by C5.0 to work, dataset will be grouped every three consecutive levels, say levels 3, 4 and 5. The result is that C50 obtains a set of rules, able to classify exactly the 33 cases of ” LOW” groups from level 3 on, that is, from one third of the assignment period, with a p value $p = 1.24e - 14$ statistically very relevant. In addition, the rules obtained make complete sense, like those shown in Figure 9. For example Rule 13 says: ” A group is at risk if the behavior is messed up with a degree $Dm > 1.93$ much higher than expected 1.06 (Figure 8) and they are just focused on the minor problems $Be <= 4$, that is, they have not explored yet other more complex problems” . Or Rule 11, which says ” A group is at risk if they do not have few sessions $We > 0.12$ but their behavior starts to be more lengthy ($Le <= -0.69$) much longer than expected (-8.6) and the graph seems not too connected ($St < 2$, expected 1.1). This is like the bad graph shown early in this paper in Figure 1, lengthy and unconnected.

But not only this, could we go a big step and predict not only ” LOW” /” GOOD” teams but also both a lower and an upper bound of their final grades, and guess in which of the 5 intervals of Figure 7 will end up? The answer is, happily yes, but this is another story to be told in another shortcoming study.

VII. BRIEF CONCLUSIONS

This study has proven several hypothesis. The most important one is that groups at risk can be detected right from the first third of the laboratory period with a important evidential significance. A second one is that this can be done just by watching their behavior from a topological point of view, something also intuitive because all of us know what we do when we are lost: wandering around in non-sense transitions. And third, the early detection might be probably due to the fact that the first stages are crucial for the rest, and the most important mistakes and misleading happen very soon, right at the beginning.

REFERENCES

[1] L. Castillo and F. Sa´nchez-Carrascosa, “Larva: Learning analytics recollection and visualization agents,” in *2022 International Symposium on Computers in Education (SIIE)*. IEEE, 2022, pp. 1–6.
[2] ——, “Larva, a multiagent system to collect learning analytics and provide immediate feedback to students during laboratory assignments,” *IE Comunicaciones. Revista Iberoamericana de Informa´tica Educativa*, no. 37, pp. 33–43, 2023.
[3] L. Castillo, “A virtual laboratory for multiagent systems: Joining efficacy, learning analytics and student satisfaction,” in *International Symposium on Computers in Education (SIIE)*, IEEE, Ed., 2016, pp. 1–6.
[4] F. S. Keller, “Good-bye, teacher...” *Journal of applied behavior analysis*, vol. 1, no. 1, p. 79, 1968.
[5] R. Elmoazen, M. Saqr, M. Khalil, and B. Wasson, “Learning analytics in virtual laboratories: a systematic literature review of empirical research,” *Smart Learning Environments*, vol. 10, no. 1, pp. 1–20, 2023.
[6] P. Mukala, J. Buijs, M. Leemans, and W. van der Aalst, “Learning analytics on coursera event data: A process mining approach,” in *5th International Symposium on Data-Driven Process Discovery and Analysis (SIMPDA 2015*. CEUR-WS. org, 2015, pp. 18–32.
[7] C. dos Santos Garcia, A. Meincheim, E. R. F. Junior, M. R. Dallagassa, D. M. V. Sato, D. R. Carvalho, E. A. P. Santos, and E. E. Scalabrin, “Process mining techniques and applications–a systematic mapping study,” *Expert Systems with Applications*, vol. 133, pp. 260–295, 2019.
[8] A. Bogar´ın, R. Cerezo, and C. Romero, “A survey on educational process mining,” *Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery*, vol. 8, no. 1, p. e1230, 2018.
[9] A. Bogar´ın Vega, R. Cerezo Mene´ndez, C. Romero *et al.*, “Discovering learning processes using inductive miner: A case study with learning management systems (lmss),” Psicothema, 2018.
[10] L. Juhanˇa´k, J. Zounek, and L. Rohl´ıkova´, “Using process mining to an- alyze students’ quiz-taking behavior patterns in a learning management system,” Computers in Human Behavior, vol. 92, pp. 496–506, 2019.
[11] G. Sedrakyan, J. De Weerdt, and M. Snoeck, “Process-mining enabled feedback:“tell me what i did wrong” vs.“tell me how to do it right”,” Computers in human behavior, vol. 57, pp. 352–376, 2016.
[12] W. M. van der Aalst, Process mining: data science in action. Springer, 2016.
[13] C. W. Gu¨nther and W. M. Van Der Aalst, “Fuzzy mining–adaptive process simplification based on multi-perspective metrics,” in Business Process Management: 5th International Conference, BPM 2007, Brisbane, Australia, September 24-28, 2007. Proceedings 5. Springer, 2007,
[14] pp. 328–343.
[15] C. W. Gu¨nther and A. Rozinat, “Disco: Discover your processes.” BPM (Demos), vol. 940, no. 1, pp. 40–44, 2012.
[16] T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, Introduction to algorithms. MIT press, 2022.
[17] J. R. Quinlan, “Data mining tools see5 and c5. 0,” http://www. rulequest.

com/see5-info. html, 2004.

RETO DE ECUACIONES, UNA APLICACIÓN DE APOYO A LA CLASE DE MATEMÁTICAS

Reto de ecuaciones, an app to support mathematics lessons

Pablo Delgado Rodríguez
Máster del Profesorado de Educación Secundaria, especialidad Matemáticas
Universidad Rey Juan Carlos
Móstoles, Madrid, España
Departamento de Bioingeniería
Universidad Carlos III de Madrid
Leganés, Madrid, España
https://orcid.org/0000-0002-5991-7791

Raquel Hijón Neira
Departamento de Informática y Estadística
Universidad Rey Juan Carlos
Móstoles, Madrid, España
https://orcid.org/0000-0003-3833-4228

Celeste Pizarro Romero
Departamento de Matemática Aplicada
Universidad Rey Juan Carlos
Móstoles, Madrid, España
https://orcid.org/0000-0003-2447-8239

Resumen—Durante los últimos años los usos de tecnologías digitales han aumentado en la enseñanza y sus beneficios académicos se han demostrado, por lo que el desarrollo de una app para el aprendizaje de las matemáticas puede resultar en una herramienta útil para los alumnos. En este proyecto se ha desarrollado una app para la que se ha tenido en cuenta que debería cumplir una serie de criterios, incluyendo estar centrada en el tema de ecuaciones de 4º de la ESO y utilizar vídeos de teoría. Se han revisado aplicaciones anteriores sin encontrar otra que cumpla exactamente todos los puntos requeridos. "Reto de ecuaciones" se ha diseñado en App Inventor, y está disponible para Android en https://sites.google.com/view/reto-de-ecuaciones/inicio. Incluye un avatar para guiar al alumno y ofrece contenido sobre seis tipos de ecuaciones: segundo grado, bicuadradas, racionales, radicales, exponenciales y logarítmicas. Para cada tipo incluye teoría en forma de vídeo, además de dos cuestionarios de nivel bajo y alto, con los que el alumno puede medir sus progresos. Esta aplicación ayudará a aumentar el interés de los alumnos por la materia y les permitirá poner a prueba sus habilidades en cualquier lugar. De cara al futuro se plantea la prueba en una clase real para evaluar su efectividad, así como la traducción al inglés para aumentar su alcance.

Palabras clave—ecuaciones, app móvil, aprendizaje con vídeos, cuestionarios, avatar

Abstract—During the last few years, the use of digital technologies for teaching has increased and its academic benefits have been demonstrated, so the development of an app for learning mathematics can prove to be a useful tool for students. During this project an app has been developed taking into account that it should meet a series of criteria, including being focused on the subject of equations in 4th ESO and utilizing theory videos. Previous apps have been reviewed but no other one has been found to meet all the required criteria. "Reto de ecuaciones" has been designed in App Inventor and is available for Android at https://sites.google.com/view/reto-de-ecuaciones/inicio. It features an avatar to guide the student and offers content on six types of equations: quadratic, biquadratic, rational, radical, exponential and logarithmic. For each type, it includes theoretical content as videos, as well as two quizzes (low and high level) against which the student can measure their progress. This application will help increase students' interest in the subject and allow them to test their skills anywhere. Looking ahead, we are considering testing in a real classroom to evaluate its effectiveness, as well as translating the app into English to increase its reach.

Keywords—equations, mobile app, learning through videos, questionnaire, app

I. INTRODUCCIÓN

En los últimos tiempos se está viendo un claro cambio de paradigma en cuanto al enfoque que se da al proceso educativo. El mundo de hoy en día está lleno de estímulos inmediatos, sobre todo a raíz de Internet, y las generaciones más jóvenes son las que más interiorizado tienen su uso, ya que han nacido cuando ya existía. Los alumnos que ahora mismo se encuentran en los centros de Educación Secundaria nacieron después de que se crearan las principales redes sociales, por lo que han pasado toda su vida rodeados por las redes y la tecnología, que para ellos es algo totalmente natural. Las redes sociales actuales están extendiendo el consumo de contenido de corta duración, por lo que la sociedad actual se está acostumbrando a saltar con rapidez de un tema al siguiente, sin mantener la atención fija en algo durante demasiado tiempo.

Para poder ofrecer a los estudiantes de Educación Secundaria la mejor formación posible es necesario adaptarse a los tiempos, lo que significa aceptar el uso de herramientas alternativas que puedan ayudar a despertar y mantener su interés. Esto es especialmente patente en asignaturas que tradicionalmente suponen un mayor esfuerzo para gran parte de los estudiantes, como son las matemáticas. Su aprendizaje requiere un nivel de abstracción y una comprensión a fondo de su lenguaje para las que es necesario prestar atención y entender a fondo los conceptos, no simplemente memorizar soluciones. Al contrario de otras asignaturas en las que el papel de la memorización es mucho mayor (por ejemplo, historia), en las matemáticas lo que importa de verdad es el desarrollo de métodos para resolver problemas, que deben ponerse a prueba y utilizarlos en sus ejercicios hasta que se conviertan en algo natural.

Dado que las matemáticas pueden resultar especialmente problemáticas para los alumnos, se ha experimentado con la puesta en marcha de métodos alternativos para su enseñanza. En su mayoría esto implica la realización de algún tipo de juego en el que se trabajen conceptos matemáticos y que permita la implicación de los alumnos en un entorno competitivo o cooperativo. Éstos pueden consistir en juegos físicos, como los de mesa o de cartas, que aportan un elemento tangible que puede ayudar a hacer más reales las ideas abstractas de las matemáticas. Por otro lado, el uso de recursos virtuales tiene también sus ventajas. Un juego online o un programa que los alumnos puedan usar para realizar actividades puede conectar de forma más directa con su realidad, lo que puede ayudar a que dejen de ver las matemáticas como una tarea tediosa y piensen en ellas como un pasatiempo. Estudios como [1] analizan el impacto de este tipo de juegos en los resultados académicos. Por lo general se observan resultados prometedores, sobre todo en cuanto a mejora del interés.

El mayor exponente de estas tecnologías es el teléfono móvil. Ahora mismo casi la totalidad de los adolescentes de secundaria tienen un móvil personal, que utilizan para comunicarse, buscar información, entretenerse o pedir comida. Se ha convertido en una herramienta casi indispensable. Dado que utilizan el móvil con mucha frecuencia y que en la mayoría de los casos está prohibido en el centro, es normal que en un principio no lo asocien con sus estudios. Es por esto que, dentro de las posibles herramientas que se pueden usar para fomentar el aprendizaje de las matemáticas, una aplicación de móvil resulta una opción que debería permitir llegar a los alumnos de forma sencilla.

En este trabajo se presenta el diseño de una aplicación para Android para proporcionar una plataforma en la que alumnos de 4º de la ESO puedan practicar sobre un tema concreto de la materia: la resolución de ecuaciones. La aplicación incluye explicaciones teóricas en vídeo para aprender a resolver los diferentes tipos de ecuaciones que se explican en este curso, además de cuestionarios de varios niveles de dificultad. Incluye un avatar que les irá guiando por las diferentes pantallas y hará la experiencia más cercana. La aplicación se ha programado desde cero utilizando la herramienta App Inventor, del Massachusetts Institute of Technology (MIT) [2], que trabaja mediante programación por bloques, la cual facilita la comprensión del código. Se ha tenido esto en cuenta porque otro de los posibles usos futuros de la aplicación podría ser el servir como ejemplo para que los alumnos aprendan las bases de la programación. La app se encuentra disponible para descargar de forma gratuita como archivo .apk de instalación para Android en una página web creada con este propósito. En esta web se presenta la app y se explica cómo utilizarla y navegar por sus pantallas. Se puede acceder a esta web a través del siguiente enlace: https://sites.google.com/view/reto-de-ecuaciones/inicio. En la sección 2 se repasa el estado de la cuestión, la sección 3 explica el diseño de la aplicación, la sección 4 detalla su funcionalidad y su difusión y por último, la sección 5 recoge las conclusiones.

II. Estado del arte

Durante los últimos años el uso de tecnologías digitales para mejorar el aprendizaje en secundaria ha ido incrementándose progresivamente. Trabajos como [3] documentan los efectos académicos positivos de juegos 3D matemáticos de ordenador, como ejemplo de herramienta digital. También se ha estudiado el uso en general de determinados dispositivos, como las tablets, lo que se puede ver en [4]. En cuanto a los móviles en concreto, el interés por el uso de aplicaciones y sus efectos en el desempeño en secundaria ha dado lugar a análisis como [5], donde se evalúa una aplicación con pruebas de diferentes materias para ver la reacción de los alumnos, que es en conjunto positiva. Además, estudios como [6] dan una idea de la gran cantidad de pruebas que se han hecho en estudiantes de secundaria para comprobar los beneficios del uso de juegos móviles para aprender matemáticas y ciencia. No solo han demostrado su utilidad en general, sino que las aplicaciones móviles también pueden ser útiles para ayudar a alumnos con dificultades específicas, como puede ser el autismo [7], ya que reducen la ambigüedad que puedan recibir de instrucciones habladas al tener una serie de ejercicios y actividades interactivas escritos.

Para diseñar una app que resultara útil para los alumnos se definieron una serie de objetivos que debería cumplir:

- Que fuera completamente gratuita.

- Que se centrara en un tema concreto, específicamente en la resolución de ecuaciones de 4º de la ESO, incluyendo estos tipos:
  - De segundo grado
  - Racionales
  - Radicales
  - Exponenciales
  - Logarítmicas

- Que incluyera contenido teórico en forma de vídeos para hacer más dinámico el aprendizaje.

Se realizó una revisión de aplicaciones disponibles actualmente, pero no se encontró ninguna que cumpliera todos los requisitos. Aplicaciones como “Khan Academy” [8] son de alta calidad y ofrece un gran rango de conocimiento para todos los niveles, pero pueden ser en cierto modo abrumadoras y lo que se buscaba con la nueva aplicación es que estuviera centrada en un tema concreto para ayudar a los alumnos a focalizarse. “Brilliant” [9] es otra opción similar, pero que requiere pago, lo que estaría totalmente descartado, al ir a implementarse en la enseñanza pública y gratuita. Otras aplicaciones, en cambio, como “PhotoMath” [10] o “MathPapa” [11] consisten en calculadoras automáticas capaces de resolver ecuaciones u operaciones a partir de la cámara del móvil, pero no plantean problemas ni teoría al usuario. Por otro lado, programas como “GeoGebra geometría” [12] están más centrados en geometría, y otros como “The fun Way to Learn Algebra” [13] o “Trucos de matemáticas” [14] están pensados para cursos más bajos.

III. Diseño de la aplicación

Para programar la aplicación se ha elegido la plataforma App Inventor, del MIT [2], que se basa en el uso de bloques de “código”. Esta es una herramienta didáctica que tiene usos muy interesantes para enseñar las bases de la programación, y se ha escogido para que en un futuro esta app pueda servir como ejemplo en caso de que se quiera enseñar a los alumnos principios de programación.

La Ilustración 1 presenta las pantallas que componen la app y sus conexiones entre ellas. A todas ellas se puede volver por el mismo camino por el que se accedió a ellas, permitiendo así navegar por la aplicación. Desde el menú principal se puede acceder a la pantalla principal de ecuaciones cuadráticas, bicuadradas, racionales, radicales, exponenciales o logarítmicas, y desde cada una de ellas se tendrá la opción de acceder a un vídeo de teoría, a un cuestionario de nivel 1 y a un cuestionario de nivel 2.

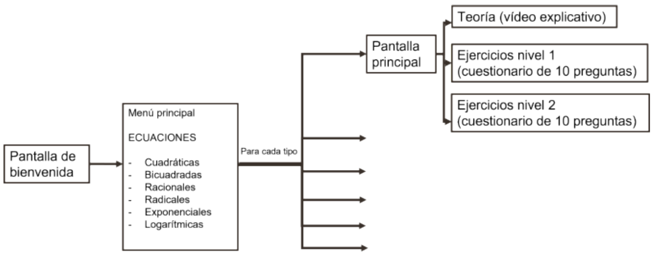


Ilustración 1: Esquema de las pantallas de la aplicación

Para hacer la experiencia más entretenida y cercana para el usuario se ha creado un avatar que lo acompañará, llamado Álex, y que hablará en forma de pequeños fragmentos de texto. Se ha puesto especial atención en generar un avatar de género ambiguo, con la intención de presentar un personaje con el que personas de cualquier género puedan sentirse identificadas. Es por ello que en ningún lugar de la aplicación Álex se refiere a sí mismo/a de forma masculina o femenina. Se han creado diferentes versiones de Álex para que sea posible cambiar de una a otra dentro de la app y generar la sensación de que está hablando, además de poder hacer que cambie de expresión dependiendo de si está contento/a o no (Ilustración 2).

Ilustración 2: Diferentes expresiones de Álex

IV. APP RETO DE ECUACIONES

A. *Pantallas iniciales*

La aplicación comienza con una pantalla de bienvenida en la que Álex se presenta y le pide al usuario que pulse el botón para que siga hablando, y más adelante para avanzar a la siguiente pantalla (Ilustración 3). Cuando se usa la app se puede observar su boca moverse mientras habla gracias a una animación que cambia entre diferentes caras con la boca abierta o cerrada. Este botón en la parte inferior derecha se utilizará en general a lo largo toda la app para continuar con lo que diga el avatar.

Ilustración 3: Pantalla de bienvenida de la app

Después de la pantalla de bienvenida se pasa al menú principal (Ilustración 4) en el que se presenta al usuario con 6 tipos de ecuaciones diferentes (los que se explican en 4º de la ESO). Al pulsar cualquiera de ellos Álex le dirá unas palabras de ánimo y la pantalla cambiará para mostrar un submenú, en el que se presentarán 3 opciones para el tipo concreto de ecuaciones: teoría, ejercicios de nivel 1 y ejercicios de nivel 2, como se puede ver por ejemplo para las ecuaciones bicuadradas en la Ilustración 5. En esta pantalla también aparece un botón arriba a la izquierda con un icono de flecha que permite volver a la pantalla anterior, y que estará presente en la mayoría de las pantallas de la aplicación para ayudar al usuario a que navegue entre ellas.

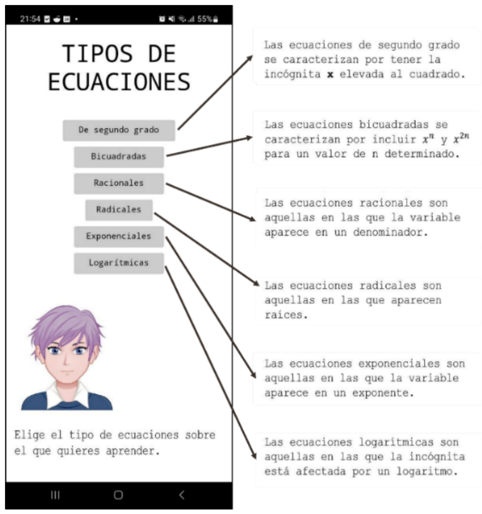


Ilustración 4: Pantalla del menú principal con los 6 tipos de ecuaciones disponibles

Ilustración 5: Submenú correspondiente a un tipo de ecuación (bicuadradas en este caso)

B. Contenido teórico

La primera de ellas es la de teoría, que nos llevará a una pantalla en la que Álex nos explica muy brevemente lo que caracteriza a ese tipo concreto de ecuaciones (Ilustración 6.A) y nos ofrece un botón que nos llevará a un vídeo explicativo para ayudar a resolverlas (Ilustración 6.B). Se utilizó un brazo extensible fijado a la mesa para sujetar un móvil sobre ésta y grabar el vídeo mientras se realizaba la explicación escribiendo en una hoja. En cada vídeo se grabó una explicación del tipo de ecuaciones concretas, las estrategias para resolverlas y algunos ejemplos. La duración de cada uno de los 6 archivos grabados para este proyecto está en el rango de 6 y medio a 15 minutos, por lo que su tamaño es considerable, ocupando los 6 vídeos en total más de 6 GB. Mientras que el resto de imágenes que aparecen en la app han sido subidas al servidor de App Inventor y vienen empaquetadas en el archivo de instalación .apk, los vídeos de teoría se integraron de otra forma debido a su gran tamaño, ya que resultarían en una app demasiado pesada y causarían problemas con el software. Es por ello que se decidió publicarlos en un canal de Youtube y enlazar la app con ellos al pulsar el botón correspondiente. De esta forma se mantuvo la funcionalidad y se consiguió una aplicación ligera.

C.

A.

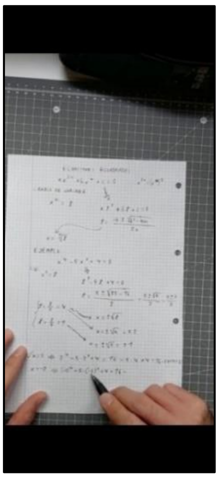
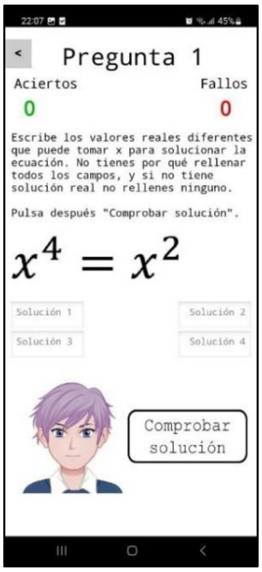

B.


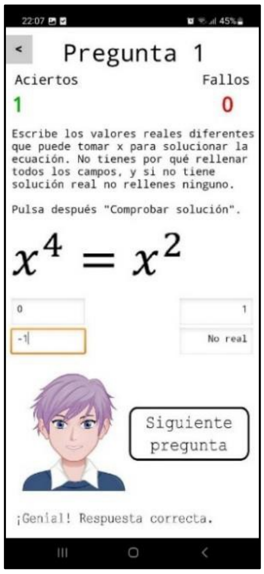
Ilustración 6: A. Pantalla de presentación de la teoría de ecuaciones bicuadradas; B. Vídeo explicativo de estas ecuaciones

Cuestionarios

Las otras dos opciones que se presentan en la pantalla inicial de cada tipo de ecuaciones (Ilustración 5) son dos cuestionarios diferentes de ejercicios, de nivel 1 y 2. El cuestionario de nivel 1 sirve para ir familiarizándose con las ecuaciones más sencillas del tipo elegido, mientras que el de nivel 2 presenta retos más complicados. Los dos siguen la misma estructura, pero cambian las ecuaciones que aparecen en cada uno. Tanto las ecuaciones como sus soluciones están preestablecidas. Después de pulsar el botón para acceder a los ejercicios de nivel 1 o 2 aparecerá la pantalla de inicio del cuestionario, y al pulsar "Comenzar" la prueba empezará. Cada cuestionario consiste en 10 ecuaciones diferentes para las que el usuario tendrá que intentar encontrar los valores de x reales que son solución. Hay dos tipos de preguntas: en el primer tipo se pide al usuario que introduzca los valores diferentes de x que son solución real (4 valores como mucho, en 4 campos distintos). Se explica en el enunciado que no hay por qué escribir una solución en cada uno de los campos (puede haber menos de 4). En la Ilustración 7.A se muestra un ejemplo de una de estas ecuaciones, y en la Ilustración 7.B el mensaje que aparece al introducir en ella una solución correcta. La aplicación ofrece un mensaje negativo cuando el usuario falla la pregunta y uno positivo al acertarla. Los aciertos y fallos se registran además en la parte superior en verde y rojo respectivamente. Si se llega a 10 aciertos se completa el cuestionario con éxito.



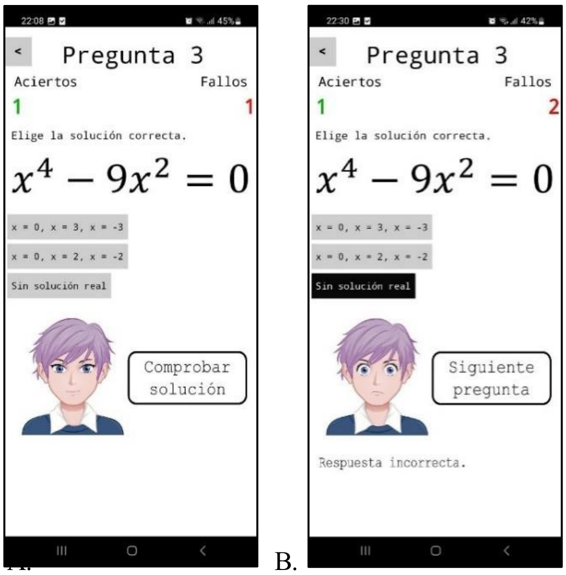
A.



B.

Ilustración 7: A. Ejemplo de pregunta para escribir soluciones; B. Mensaje al introducir una solución correcta

El segundo tipo de pregunta es de múltiple respuesta, y en ella se debe elegir una de las tres opciones, en las que se dan unos valores para las soluciones reales de la ecuación. En la Ilustración 8.A se ve un ejemplo de este tipo de ecuaciones, mientras que en la Ilustración 8.B aparece el mensaje que se da al responderla erróneamente. En cualquiera de los dos casos, después de introducir la respuesta se pulsa "Comprobar solución" para ver si es correcta. Los fallos y aciertos del usuario se van registrando en la parte superior de la pantalla.



A. B.

Ilustración 8: A. Ejemplo de pregunta de respuesta múltiple; B. Mensaje al introducir una solución incorrecta

Las ecuaciones y soluciones de los cuestionarios han sido extraídas de diversas fuentes libres de derechos e introducidas en la app como imágenes a las que el código haría referencia más tarde para presentarlas en la pantalla.

D. Difusión de la app

Para facilitar la difusión de la app se ha creado una página web del proyecto, a la que se puede acceder siguiendo el siguiente enlace: https://sites.google.com/view/reto-de-ecuaciones/inicio. En ella se presenta la aplicación y se habla sobre qué incluye, cómo navegar por sus pantallas y se ofrece un enlace para poder descargar el archivo .apk que permita instalarla en un dispositivo Android (Ilustración 9). Además, un vídeo de demostración sobre el uso de la app está disponible en este enlace: https://youtu.be/ABiidn5cnxY, así como en la página web.

Ilustración 9: Página web de distribución de la aplicación

V. CONCLUSIONES

Uno de los principales problemas para el aprendizaje de las matemáticas en los alumnos de secundaria es su dificultad para mantener la atención y conectar con la asignatura. Dada la alta conexión con la tecnología que muestran los alumnos actuales se pueden obtener buenos resultados utilizando herramientas digitales para complementar su aprendizaje, como indican diversos estudios. En concreto el uso de teléfonos móviles puede conectar fácilmente con ellos, ya que los utilizan constantemente en su día a día. Es por esto que se ha decidido crear una aplicación para Android que ayude en un tema concreto de matemáticas, la resolución de ecuaciones en 4º de la ESO. Para crear una herramienta útil en esta tarea concreta se han definido una serie de puntos que debería cumplir, que incluyen que sea gratuita, que se centre en ecuaciones de 4º de la ESO y que no presente un temario demasiado amplio y que incluya vídeos de teoría para enseñar a resolverlas. Se ha realizado un análisis de otras aplicaciones de matemáticas y no se ha encontrado una que cumpliera exactamente todos los puntos, por lo que se ha procedido a desarrollarla

La aplicación, llamada “Reto de ecuaciones”, cubre los principales tipos de ecuaciones con los que se trabaja en la asignatura de matemáticas de 4º de la ESO, es decir: cuadráticas, bicuadradas, racionales, radicales, exponenciales y logarítmicas. Es gratuita y se puede descargar a partir de un sitio web creado para la ocasión, en el cual se explican sus contenidos y se da un enlace para descargar su archivo .apk y poder instalarla. Ha sido diseñada utilizando la herramienta App Inventor, del MIT y utiliza un avatar (Álex) que guía al usuario a lo largo de ella y que ha sido diseñado sin un género determinado para facilitar que el usuario pueda sentirse identificado independientemente de su identidad.

Para cada uno de los seis tipos de ecuaciones se incluye un apartado de teoría con enlace a un vídeo en el que se explica en qué consiste ese tipo y cómo resolverlas. Además, se puede acceder a dos cuestionarios de 10 preguntas cada uno, uno de nivel bajo y otro de nivel alto. Las preguntas consisten en ecuaciones para las que hay que dar las soluciones reales, ya sea introduciendo los valores o seleccionando la respuesta correcta de entre varias. Los fallos y aciertos se van anotando y no es posible volver atrás, para incentivar que los usuarios intenten cada cuestionario hasta que consigan responder las 10 preguntas correctamente de un solo intento. Los profesores pueden acceder a las soluciones a los cuestionarios en la siguiente web:

https://sites.google.com/view/retodeecuaciones-solucinaloscu

Esta herramienta puede servir como complemento para que los alumnos puedan tener una serie de ejercicios de ecuaciones accesibles en todo momento y puedan practicar en cualquier parte. Esto facilitará que desarrollen las destrezas necesarias para resolver esta parte del temario.

VI. TRABAJO FUTURO

El siguiente paso para poner a punto la aplicación sería probar su efectividad con usuarios reales. Se diseñaría un cuestionario utilizando alguna herramienta como Google Forms en el que se incluirían algunas de las ecuaciones que aparecen en los cuestionarios de la app, elegidas aleatoriamente de entre todos ellos. Se pasaría el cuestionario inicialmente a alumnos para ver si tienen dificultades para resolverlas. Luego se les enviaría la app y se dejaría que trabajasen un tiempo con ella. Después de esto se volvería a pasar otro cuestionario, de nuevo extrayendo aleatoriamente ecuaciones de la app, para determinar si la aplicación les ha ayudado y han mejorado sus habilidades de resolución de ecuaciones.

Además de esto, se tendría en cuenta la traducción de la app al inglés para poder distribuirla de forma internacional, y se plantearía en el futuro su conversión a instalador para iOS, funcionalidad actualmente restringida en App Inventor.

Bibliografía

[1] A. S. Drigas and M. A. Pappas, "On line and other game-based learning for mathematics," *Int. J. Online Eng.*, vol. 11, no. 4, pp. 62–67, 2015.

[2] "MIT App Inventor." [Online]. Available: https://appinventor.mit.edu/. [Accessed: 03-Jun-2023].

[3] M. Kebritchi, A. Hirumi, and H. Bai, "The effects of modern mathematics computer games on mathematics achievement and class motivation," *Comput. Educ.*, vol. 55, no. 2, pp. 427–443, 2010.

[4] L. Zhang and J. Nouri, "A systematic review of learning and teaching with tablets," in *Proceedings of the 14th International Conference on Mobile Learning 2018, ML 2018*, 2018, pp. 79–88.

[5] Z. Karabatzaki *et al.*, "Mobile application tools for students in secondary education. An evaluation study," *Int. J. Interact. Mob. Technol.*, vol. 12, no. 2, pp. 142–161, 2018.

[6] M. Bano, D. Zowghi, M. Kearney, S. Schuck, and P. Aubusson, "Mobile learning for science and mathematics school education: A systematic review of empirical evidence," *Comput. Educ.*, vol. 121, pp. 30–58, Jun. 2018.

[7] A. Stathopoulou, Z. Karabatzaki, D. Tsiros, S. Katsantoni, and A. Drigas, "Mobile apps the educational solution for autistic students in secondary education," *Int. J. Interact. Mob. Technol.*, vol. 13, no. 2, pp. 89–101, Feb. 2019.

[8] "Khan Academy - Apps en Google Play." [Online]. Available: https://play.google.com/store/apps/details?id=org.khanacademy.android&hl=es_419&gl=US&pli=1. [Accessed: 02-Jun-2023].

[9] "Brilliant - Aplicaciones en Google Play." [Online]. Available: https://play.google.com/store/apps/details?id=org.brilliant.android&hl=es&gl=US. [Accessed: 02-Jun-2023].

[10] "Photomath - Aplicaciones en Google Play." [Online]. Available: https://play.google.com/store/apps/details?id=com.microblink.photomath&hl=es&gl=US. [Accessed: 02-Jun-2023].

[11] "MathPapa - Algebra Calculator - Aplicaciones en Google Play." [Online]. Available: https://play.google.com/store/apps/details?id=com.mathpapa.mathpapa&hl=es&gl=US. [Accessed: 02-Jun-2023].

[12] "GeoGebra Geometría - Apps en Google Play." [Online]. Available: https://play.google.com/store/apps/details?id=org.geogebra.android.geometry&hl=es_MX. [Accessed: 02-Jun-2023].

[13] "The Fun Way to Learn Algebra - Apps on Google Play." [Online]. Available: https://play.google.com/store/apps/details?id=com.handsonequationslite1&hl=en. [Accessed: 02-Jun-2023].

[14] "Trucos de Matemáticas - Apps en Google Play." [Online]. Available: https://play.google.com/store/apps/details?id=example.matharithmetics&hl=es_419&gl=US. [Accessed: 02-Jun-2023].

PROMOTING GLOBAL AWARENESS OF THE SDGS IN THE CLASSROOM THROUGH THE SDGCALENDAR PLATFORM

Ezequiel Jiménez-García
Department of Computer Science
University of Cádiz
Cádiz, Spain
ezequiel.jimenezgarcia@alum.uca.es

M. Carmen de Castro-Cabrera
Department of Computer Science
University of Cádiz
Cádiz, Spain
maricarmen.decastro@uca.es

Sara Balderas-Díaz
Department of Computer Science
University of Cádiz
Cádiz, Spain
sara.balderas@uca.es

Gabriel Guerrero-Contreras
Department of Computer Science
University of Cádiz
Cádiz, Spain
gabriel.guerrero@uca.es

***Abstract*—This paper presents the design of SDGCalendar, an ecosystem of both a mobile and web application that aims to introduce the teaching of Sustainable Development Goals (SDGs) in schools. This system employs current technologies to deliver a robust and intuitive user experience to both students and teachers, by providing access to SDGs, international days related to SDGs (hence the name SDGCalendar), and activities and questionnaires.**

To evaluate the viability of the project, two separate usability tests were conducted with distinct user groups to test the interface of the mobile implementation, SDGCalendar APP. Preliminary findings reveal that SDGCalendar APP is not only user-friendly but also highly efficient in performing its intended functions, while highlighting areas for improvement, providing valuable insights that will guide future development, such as readability. With SDGCalendar, we believe it is possible to raise awareness of the SDGs inside schools while making it enjoyable to both teachers and students.

***Index Terms*—education, App, Sustainable Development Goals (SDGs), interface evaluation, interface validation**

I. INTRODUCTION

Established in 2015 by the United Nations General Assembly and intended for achievement by 2030, the Sustainable Development Goals (SDGs) consist of 17 finite goals and 169 targets oriented to provide strategies that improve education, and health, foster economic growth, reduce climate change and reduce inequalities among humanity [11]. Nowadays, 193 countries are cooperating in a *"blueprint to achieve a better and more sustainable future for all"* that gathers a consensus of global goals to be applied in all countries of the world [14]. There is a correlation between the targets of the same SDG which implies that the achievement of one target reinforces progress on other targets and goals [4]. In particular, the interaction between SDGs 1 (*"No Poverty"*), 4 (*"Quality Education"*), 5 (*"Gender Equality"*), 10 (*"Reduced Inequalities"*), 11 (*"Sustainable Cities and Communities"*), 13 (*"Climate Action"*), 14 (*"Life Below Water"*) and 16 (*"Peace, Justice and Strong Institutions"*) generates a significant portion, ranging from 80% to 100%, of the synergies observed [4].

In recent years, efforts are being made to promote global education as a cornerstone to achieve the goals defined within the SDGs [19]. Simultaneously, a number of initiatives have addressed important issues, including the engagement of numerous stakeholders, reinforcing legal obligations, incorporating sustainability issues throughout the learning environ- ment, fostering critical thinking, participatory and problem- based learning approaches, integrating sustainability educa- tion, adopting systems thinking, and developing self-awareness [19]. Institutions of higher education are actively working to promote a sustainable society through principles integrated within the syllabus, research programs, and the active partici- pation of staff and students [19]. Education is on the frontline of all forms of development from primary school to higher education and lifelong learning [19].

In this paper, we present a platform called SDGCalendar to promote and raise awareness of the SDGs. Our target audience, in this study, is stakeholders (i.e., children, their families, and teachers) from primary schools. SDGCalendar promotes access to content related to the SDGs, created by teachers and adapted for the correct understanding of children and their families, with the aim of raising awareness and strengthening their engagement with the SDGs.

This paper is organized as follows: Section II summarizes related work, Section III introduces the proposal: platform and subsystems, Section IV develops the interface prototyping and usability evaluation. Section V describes the discussion and results and finally, Section VI presents conclusions and future work.

II. RELATED WORK

In this section, we will briefly describe some academic papers, followed by a review of some SDG apps [12] .

In Annan and Molinari [5], the authors seek to highlight the importance of designing an interdisciplinary perspective in education for sustainable development and illustrate how to advance interdisciplinarity by recognizing different perspec- tives of sustainability and social responsibility in the context of diversity. The depth and relationship between the SDGs make it clear that different professionals from various disciplines and sectors must work together to achieve the goals. Cross- cutting issues such as climate change, poverty, and human rights demand knowledge and skills from different disciplines in an integrated manner. Interdisciplinarity fosters the ability to understand complex problems and act in line with the expected outcomes of education for sustainable development. Based on the above, the authors develop a case study with Masters in Business Administration graduate students in the context of diversity, fostering a culture of respect for people, communities, and the environment, benefiting communities, and contributing to global improvement and sustainability.

From the point of view of ethics and sustainability, Montiel et al. focus on the need for new ways of teaching through technology in a recent work [15]. There is a demand for greater use of digital content in educational activities. Likewise, they emphasize that the challenge is not in publishing digital con- tent, but in keeping the content updated and highlighted. They value relying on mobile application developers who respond with applications to the challenges of society. On the other hand, they recommend finding a balance between educational and digital human interaction, so that human contact continues to predominate between teachers and students.

In addition, Abad et al. in [3], review the evolution of research on the challenge of sustainability of management, research, and teaching activities through virtual technologies, specifically focusing on augmented reality. The results ob- tained highlight a growing interest in the study of the sus- tainability of augmented reality, as well as several outstanding lines of research, such as technological resources, computing, simulation, education, and learning. They found that interest in this topic is increasing in the scientific field and its link with the SDGs.

Regarding mobile applications, the most relevant ones are described in relation to the SDGs, focusing on their educational impact, engagement, and the existence of active users.

Ods Research & Action [10] is an application that provides an interactive platform for users to gain knowledge about the 17 SDGs. It offers a space to delve into societal challenges, engage in relevant events, and formulate sustainability- oriented proposals. Additionally, it fosters collaboration and interaction among researchers and enables content sharing across social networks. With its appealing design, regular updates, and compatibility with both major mobile ecosystems, this application stands out as the one with the most extensive user community

Ruta ODS Ecuador [9] is a mobile application specifically designed for a younger demographic. It offers unique features such as earning scores through SDG-related quizzes, viewing and initiating related projects, in-depth exploration of each SDG, and receiving updates pertinent to these goals. Furthermore, it incentivizes user engagement by awarding trophies for each completed action. While the application boasts a user-friendly design and a broad spectrum of activities, its interface is not particularly intuitive. Moreover, since its launch, it has only managed to surpass 50 downloads.

Desafio Sostenible [18] is another tool targeting a younger audience, aiming to facilitate understanding of the SDGs and encourage actions towards their achievement. It provides updates, a comprehensive list of SDGs, and notably features the *"Lazy people's guide to save the world"* - a child-friendly guide that simplifies the process of adopting SDG-aligned behaviors. However, the application's simplistic design could benefit from enhancements, and it's worth noting that its most recent update was three years ago.

The *ODS.OLACEFS* [16] platform is dedicated to disseminating information, news, and audit reports concerning sustainable development. Its key features allow users to cast votes for reports from Supreme Audit Institutions in Latin America, create rankings, engage with other users via SDG-related comments, and access news tied to the SDGs. Despite introducing innovative functionalities, the platform has yet to build a substantial user community, and it does not regularly release updates.

In summary, to the best of our knowledge, the SDGs are being promoted mainly by universities. Several applications have been developed in the last few years with the purpose of raising awareness of the SDGs. Nevertheless, most of them are aimed at the general public and are not integrated as a tool in the educational process, nor are they available for iOS which limits access to certain users, nor have updates been published since their release. Therefore, in this work we propose to integrate the SDGCalendar platform into the educational process from primary schools, it will be available for all platforms, and it will be kept updated. Teachers themselves will be able to design and configure the content according to the knowledge of their students.

III. SDGCalendar Platform and Subsystems

The SDGCalendar Platform (Figure 1) aims to provide a comprehensive suite of services and applications that enable teachers to effectively address the United Nations SDGs with their students and families.

The platform consists of three primary applications, each meeting the needs of specific user groups:

- **SDGCalendar APP**: Intended for students and their families, this mobile application provides access activities and questionnaires based around learning the SDGs, in addition to information regarding the SDGs and a calendar of Featured International Days (FIDs). This platform will be the main focus of this paper.

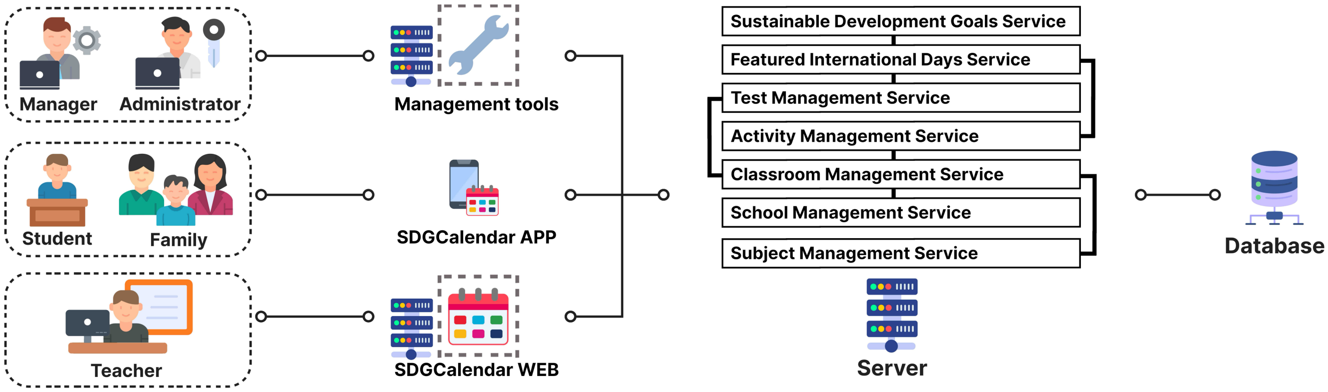


Fig. 1: SDGCalendar Platform Architecture.

- **SDGCalendar WEB**: Developed specifically for teachers, this web application enables them to create, customize and select activities and questionnaires to be assigned to their students. They can plan, organize, and track their students' answers, ensuring effective engagement with the goals alongside students and families.
- **Management Tools**: Designed for administrators and managers, Management Tools enable them to have complete control over the operations of the platform and its key technical aspects.

Developing SDGCalendar APP as a mobile application has several advantages. Firstly, being accessible from smartphones and tablets makes it easily available to users anytime and anywhere. Students and their families can conveniently access information about SDGs, complete activities, and review questionnaire answers on the go, providing flexibility and convenience. Additionally, mobile applications typically offer a more immersive and interactive user experience compared to web applications [8]. This allows students and their families to engage with the content and activities in a user-friendly and intuitive manner, promoting active participation and deeper involvement.

On the contrary, SDGCalendar WEB has been developed as a web application. This change of platform was based on the type of operations that teachers will perform, which are managing their subjects, classes, activities, questionnaires, and students. In this context, it is necessary to have a work-oriented environment, such as a desktop computer or laptop. A larger screen provides a more comfortable visual experience and facilitates the viewing of detailed content, such as documents, presentations, and graphics. Additionally, the physical keyboard makes typing and text input easier compared to virtual keyboards on smartphones. Similarly, developing the application as a web application brings various advantages, including universal access from anywhere through a device with a web browser and internet connectivity.

Regarding the implementation, the SDGCalendar WEB application has been developed using the ReactJS framework, while the SDGCalendar APP application has been built with React Native. Both applications follow the Redux design pattern [6]. This pattern involves managing the application state through a unidirectional flow of data, where information flows in a controlled manner. The application state is stored in a single centralized store, which contains the complete state of the application. As actions occur in the application, they are sent to the store through functions called reducers, which are responsible for updating the state based on the received actions. This ensures that the state is always updated in a predictable and consistent manner. By using Redux, debugging and tracking how and why the application state changes are made easier. It also promotes writing modular and reusable code, as reducers are functions independent of any state.

These applications are supported by a set of services, implemented using a classic client-server architecture based on HTTP and RESTful principles [17]. The design of the logic of the platform using services provides us with advantages such as modularity and code reuse, which facilitate platform maintenance and updates. Additionally, by separating the server logic from the user interface, greater scalability and flexibility are achieved, allowing changes to be made in the backend without affecting the user experience. Meanwhile, the client-server architecture offers advantages such as workload distribution. By performing processing and data management on the server, the load on client devices is reduced, resulting in better performance and a smoother user experience.

The backend functionality is provided through a REST API, due to the interoperability it offers. REST APIs are easy to maintain, simplifying application development and facilitating integration with other systems. To manage the reliability of communications between the client and the server, the open standard JWT (JSON Web Token) is used [13]. JWT enables efficient authentication and authorization, as the server can verify and validate the digitally signed token without the need to consult a database or maintain a session state.

The main services comprising the backend are:

- **Sustainable Development Goals (SDGs) Service**, which allows for viewing and managing (creating, modifying, and deleting) the SDGs stored in the system. Every SDG is related to various FIDs. Only administrators and managers have permission to manage SDGs, while all users have permission to view them.

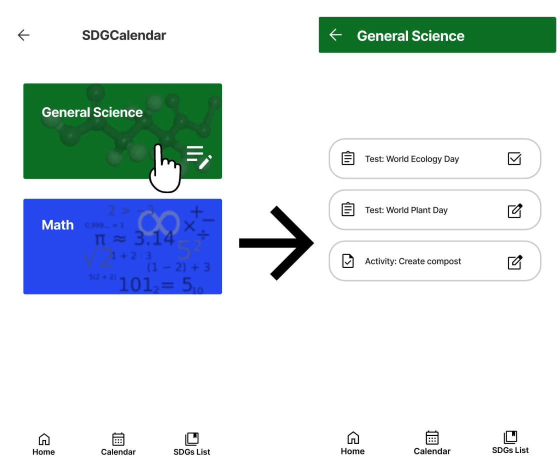
- **Featured International Days (FIDs) Service**, which allows for viewing and managing the FIDs stored in the system. FIDs are related to one or various SDGs. Only administrators and managers have permission to manage FIDs, while all users have permission to view them. In order to receive the information related to an SDG, the system will use the SDG endpoint. An example of such use is performing a GET request on the following URL: `https://[sdgcalendarserver]/SDG/2`. This action would request a JSON containing all the information regarding the SDG 2, to be displayed by the platform. A similar approach has been followed with the rest of the services.
- **Activity Management Service**, which allows for viewing and managing activities to be assigned by students. Each activity is related to one or various FIDs and one subject, activities are assigned to classrooms in order to be viewed and performed by its students. Teachers are able to create custom activities and link them to various FIDs. Only administrators, managers, and the owner (the teacher that created the activity) have permission to manage activities.
- **Questionnaire Management Service**, which allows for viewing and managing questionnaires to be taken by students, including storing and retrieving their answers. Each questionnaire is composed of various questions, every question being related to one FID. Questionnaires are assigned to classrooms in order to be viewed and performed by its students. Teachers are able to create custom questions and create a questionnaire by putting together various questions. Only administrators, managers, and the owner (the teacher that created the questionnaire or question) have permission to manage questionnaires and questions.
- **Classroom Management Service**, which is the link between teachers and students, allows teachers to submit questionnaires and activities to a classroom, as well as retrieve their answers. Students are only able to view and perform questionnaires and activities that have been assigned to their classroom. Classrooms are related to the subject taught by the teacher. A teacher can create a classroom by linking it to the school they work at, the relevant educational year, and assigning it a letter.
- **Subject Management Service** controls the creation of subjects. Activities and questions are related to a subject, but because the content and name of the actual courses can be different in distinct schools, every subject is associated with a discipline, which is a ”core” subject. When a new subject is created, it must be linked to one or more disciplines. This process allows us to sort and search activities and questionnaires/questions by discipline.
- **School Management Service** controls the creation of new classrooms and the enrollment of teachers into a school, allowing only teachers who belong to a specific school to create and manage classrooms for that school. Only administrators and managers have permission to manage schools.

IV. Interface Prototyping and Usability Evaluation

A prototype of the SDGCalendar APP interface was developed as a proof of concept and was subsequently handed over to volunteers to assess the quality of the experience through standardized usability questionnaires.

Considering that the primary target demographic is stu- dents aged between ten and twelve, a set of statements was established to shape the interface. These statements include allowing quick access to the central services of the system (ac- tivities, questionnaires, the SDGs list, and the FIDs calendar), refraining from using color as the sole medium of conveying information, providing icons and/or text consistently [2], and maintaining a contrast ratio in written text with its background that is greater than or equal to 3:1 [1].

Keeping these statements in mind, the prototype presents the user with the subjects they are associated with upon sign- in. It is accompanied by a lower menu showcasing the SDGs List and FIDs Calendar. When the user selects any subject, a list comprising both activities and questionnaires is displayed. This enables the user to access any of the items by tapping on them, as seen in Figure 2.

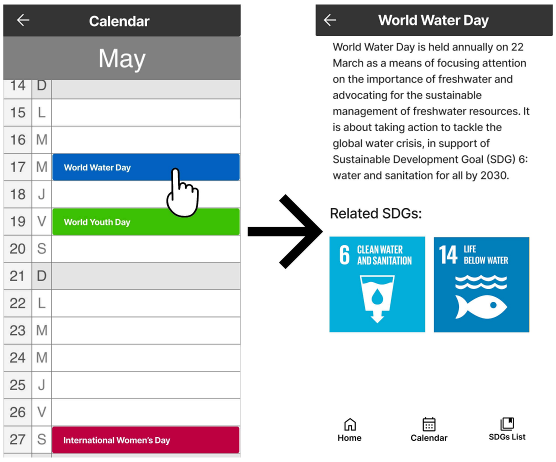


a) List of subjects b) Contents of a subject

Fig. 2: Accessing activities and questionnaires.

As it can be seen, colors are sparingly used in the inter- face, only to reinforce certain actions or options (e.g., using colors in subjects), but never to present crucial information. Another aspect is iconography, which largely uses icons from the official Android Material Design gallery. Readability is extremely important for any interface, and using familiar symbols eases and accelerates the adoption and understanding of the interface.

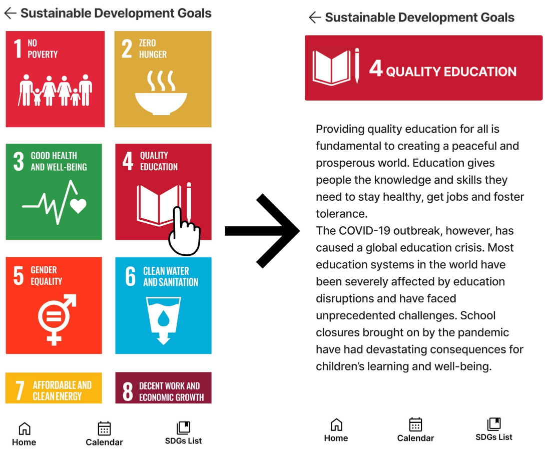
Selecting the ”FIDs Calendar” reveals a calendar with highlighted days (referred to as FIDs within the system). Upon selection, the system presents information about the FIDs as well as the related SDGs (as seen in Figure 3) while also offering the option to tap on the SDGs.



a) Showing the FIDs of May b) Inside a FID

Fig. 3: FIDs Calendar.

In a similar fashion, if the user were to open the SDGs List, they will see a two-column list encompassing all the available SDGs, allowing them to tap on any to receive more information about it, as seen in Figure 4.



a) List of SDGs b) Opening a

SDG Fig. 4: SDGs List.

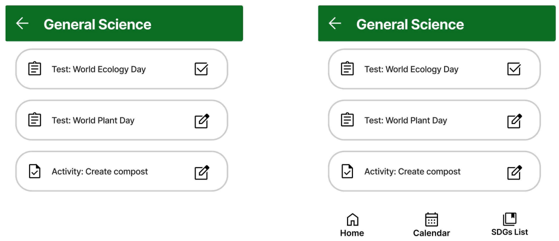
It is essential to note that the presented prototype is not the initial version, but the third. Between the original version and the current version, two comprehensive usability evaluations were conducted. To that end, the System Usability Scale (SUS) [7] test was employed. This is a proven instrument for assessing the usability of a system or interface. It is a straightforward, ten-item scale that offers a global view of subjective usability assessments.

V. Discussion of Results

The two usability evaluations were conducted in a face- to-face setting, facilitating real-time interaction between the examiners and the testers, and allowing for a comprehensive briefing prior to the questionnaire. The participants were tasked with using various features of the application, such as finding an SDG or accessing a FID.

The initial test was undertaken with a sample of 36 university students, aged between 18 and 24 years. The results obtained can be seen in Figure 6 (Evaluation 1), and after normalizing them, the total score obtained was 79.9/100 (15.98/20), which represents a medium-high usability degree of the system. Additionally, feedback from the participants in- dicated opportunities for enhancement, especially with regard to the navigability of the application.

In this matter, several participants reported that hiding the menu bar on certain screens (a feature designed to streamline navigation) unnecessarily complicated the navigability of the interface. It was necessary for them to return to the home screen every time they needed to access subjects, the SGDs List, or the FIDs Calendar. Consequently, the interface was reviewed and changes were made (Figure 5), to keep the navigation bar visible, except when the user was participating in a test or activity.



a) Before b) After

Fig. 5: Showing the navigation bar more consistently

In addition, user feedback suggested the need to clarify the scrolling capability of the FIDs Calendar interface, which resulted in the addition of an indicative hand emulating a scrolling motion through an animation. Other minor adjust- ments were also introduced, such as changing the size and position of the interactive buttons.

Subsequent to these alterations, a second usability test was conducted with a more diverse age range of participants, from 18 to 65 years, comprising 46 primary school teachers and university students of the Teaching degree. The SUS score was 81.1/100 in the second evaluation, which indicates that the modifications introduced enhanced user experience. However, as a result of the evaluation also surfaced new areas for potential improvement. Results of the first and second evaluations for each of one of the ten items evaluated in the SUS questionnaire can be observed in Figure 6 (Evaluation 2).

It should be noted that, during the evaluation, a subset of participants who were not digital natives showed frustration

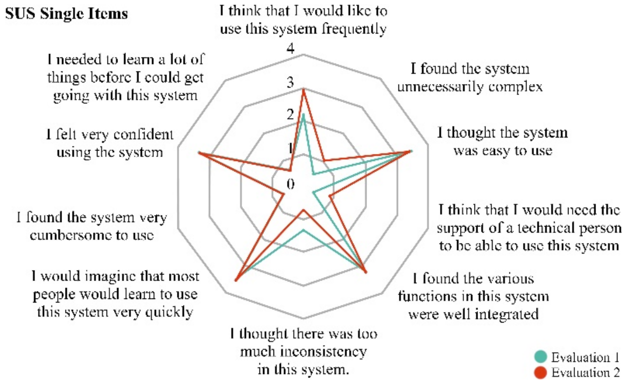


Fig. 6: SUS test Score, where 0 is ”Strongly Disagree” and 4 is ”Strongly Agree”

and confusion when navigating the interface. To address this issue, it has been proposed to introduce accessibility options into the application that would allow the user to increase the size of icons and on-screen text, thereby simplifying the inter- face and improving the user experience for this demographic.

VI. Conclusions and future work

In conclusion, the overall introduction of SDGCalendar was positively received in the SDGs domain when it was proposed to teachers. The designed user interface prototypes and implemented functions can be handled intuitively by the users. This has been demonstrated by the two usability tests conducted. In these, participants responded positively to its functionality and design, expressing satisfaction with its ease of use and the smooth user experience it provides. Suggestions for improvement identified during the evaluations have helped refine the application and will guide future development iter- ations.

However, it is important to recognize that while the results are promising, further studies with larger and more diverse groups of participants are needed to determine the broader utility and applicability of the proposed application. As a part of our future work, we intend to conduct a proof of concept study involving primary school teachers and students to assess the potential benefits of the platform in enhancing the teaching of SDGs within the classroom setting. By integrating SDGs into the curriculum and aligning them with International Highlight Days, SDGCalendar could hold the promise of making a significant impact on SDG education. We firmly believe that, through ongoing development and refinement, SDGCalendar has the potential to set a new standard for applications in this crucial educational domain.

Acknowledgment

This work has been developed with the support of the University of Cadiz through the Innovation in Education 2022/23 program.

References

[1] Web content accessibility guidelines (wcag) 2.0, https://adasitecomplia nce.com/color-blind-website-accessibility/

[2] Website accessibility for color blind, https://adasitecompliance.com/co lor-blind-website-accessibility/

[3] Abad-Segura, E., Gonzalez-Zamar, M.D., Rosa, A.L.d.l., Morales Ce- vallos, M.B.: Sustainability of educational technologies: An approach to augmented reality research. Sustainability **12**(10), 4091 (2020)

[4] Anderson, C.C., Denich, M., Warchold, A., Kropp, J.P., Pradhan, P.: A systems model of sdg target influence on the 2030 agenda for sustainable development. Sustainability science **17**(4), 1459–1472 (2022)

[5] Annan-Diab, F., Molinari, C.: Interdisciplinarity: Practical approach to advancing education for sustainability and for the sustainable development goals. The International Journal of Management Education **15**(2, Part B), 73–83 (2017). https://doi.org/https://doi.org/10.1016/j.ijme.2017.03 .006, https://www.sciencedirect.com/science/article/pii/S1472811717300 939, principles for Responsible Management Education

[6] Bertoli, M.: React Design Patterns and Best Practices. Packt Publishing Ltd (2017)

[7] Brooke, J., et al.: Sus-a quick and dirty usability scale. Usability evaluation in industry **189**(194), 4–7 (1996)

[8] Cho, M.H., Castan˜eda, D.A.: Motivational and affective engagement in learning spanish with a mobile application. System **81**, 90–99 (2019)

[9] FARO, G.: Ruta ods ecuador google play store, https://play.google.co m/store/apps/details?id=io.kodular.sethi pharaoh.hero

[10] Fudis: Ods research & action.google play store, https://play.google.co m/store/apps/details?id=com.fudis

[11] Ha´k, T., Janousˇkova´, S., Moldan, B.: Sustainable development goals: A need for relevant indicators. Ecological indicators **60**, 565–573 (2016)

[12] Jime´nez-Garc´ıa, E., de Castro-Cabrera, M., Guerrero- Contreras, G., Vargas-Vergara, M.: Ana´lisis de aplicaciones mo´viles enfocadas en los objetivos de desarrollo sostenible. In: Libro de Actas del 1º Congreso Iberoamericano para una Educacio´n de Calidad: ´Mentor´ıa y Desarrollo Competencial. pp. 245–247 (2023)

[13] Jones, M.B., Bradley, J., Sakimura, N.: Rfc 7519: Json web token (jwt) (May 2015), https://datatracker.ietf.org/doc/html/rfc7519

[14] Kubiszewski, I., Mulder, K., Jarvis, D., Costanza, R.: Toward better mea- surement of sustainable development and wellbeing: A small number of sdg indicators reliably predict life satisfaction. Sustainable Development **30**(1), 139–148 (2022)

[15] Montiel, I., Delgado-Ceballos, J., Ortiz-de Mandojana, N., Antolin-Lopez, R.: New ways of teaching: using technology and mobile apps to educate on societal grand challenges. Journal of business ethics 161, 243–251 (2020)

[16] de la Nacio´n, A.G.: Ods.olacefs. google play store, https://play.google. com/store/apps/details?id=com.agn.olacefs

[17] Ozdemir, E.: A general overview of restful web services. Applications and approaches to object-oriented software design: emerging research and opportunities pp. 133–165 (2020)

[18] Technologies, H.: Desaf´ıo sostenible. google play store, https://play.goo gle.com/store/apps/details?id=io.kodular.sethi pharaoh.hero

[19] Zˇ ale˙niene˙, I., Pereira, P.: Higher education for sustainability: A global perspective. Geography and Sustainability **2**(2), 99–106 (2021)

E-ASSESSMENT SYSTEMS: AN EVALUATION FRAMEWORK FROM THE PERSPECTIVE OF HIGHER EDUCATION EXPERTS

Pedro Isaias*
Universidade Aberta,
Lisbon, Portugal
pedro.isaias@uab.pt

Paula Miranda
Instituto Politécnico de Setúbal,
ESTSetúbal
Setúbal, Portugal

Sara Pifano
ISRLab – Information Society Research Laboratory
Lisbon, Portugal

***Abstract*— Assessment represents a central aspect of the learning process. As learning environments become more flexible and unbound by the restrictions of traditional education and as students increase in number and diversity, technology assumes a critical role in the support of a more adequate, scalable and personalised assessment. The employment of e-assessment systems can assist teachers in the development of several e-assessment initiatives, especially at a time when there is an unprecedented migration towards online learning. This paper aims to identify the essential characteristics of effective e-assessment systems by appraising an evaluation framework to assist teachers to select efficient systems. The learning technology and e-assessment experts, who completed an online questionnaire, validated the identification of the key characteristics of effective e-assessment systems: variety of assessment design options, scalability, security, accessibility and usability, feedback features, personalisation, financial cost and interoperability.**

Keywords*— *E-assessment, e-assessment systems, evaluation framework, higher education.

I. INTRODUCTION

The higher education sector is progressively implementing e-assessment, as both educators and learners are displaying higher acceptance and adoption rates [1]. E-assessment systems can be defined as systems that assist the creation, delivery and evaluation of e-assessment activities. E-assessment systems have become extremely important as assessment instruments for online learning environments. They are valuable instruments in the provision of personalised feedback to and mentoring of students. Moreover, they represent an automated solution with clear benefits in the context of large numbers of students and for assignments that might have more than one correct answer [2].

E-assessment systems, such as e-exams systems, represent an important support for e-assessment in the sense that they allow for marking automation, they offer various options in terms of question authoring, they enhance exam logistics and are a valuable source for learning analytics [3]. In a study by Guitart Hormigo, et al. [4] the authors examine the integration of dashboards within e-assessment systems to assist the decision-making process of teachers. E-assessment systems include systems for self-assessment, which students can use to assume a greater control over their learning process, and for self-intervention based on feedback [5]. In addition, e-assessment tools, such as e-portfolios, can actively contribute to the students development of digital competencies [6].

E-assessment systems are especially relevant in this era of Massive Open Online Courses (MOOC) proliferation [7] and they can be a valuable ally in the current context of massive education displacement to online settings, due to the COVID-19 pandemic [8, 9]. The use of e-assessment is expected to rise and the Covid-19 pandemic will probably intensify its use [10]. They include several e-assessment platforms and they can assume a variety of designs. As the needs of higher education evolve, so do e-assessment systems. Current e-assessment systems described in the literature [11-14] incorporate innovative technology, such as face recognition, plagiarism detection, and cloud computing, to address the needs of both teachers and students as they become more complex. While the existing assortment of available systems widens the possibilities of e-assessment delivery, it can equally constitute a challenge for teachers and institutions with concern to selecting the most appropriate system and deciding which features are required to support, create, and deliver e-assessment activities. It is therefore, essential to explore the characteristics that are fundamental for effective e-assessment systems.

Despite the importance of the selection of an appropriate e-assessment system, in a context of increasing variety, there is a lack of research that can assist teachers in making this decision and explore the criteria of an efficient e-assessment system. Hence, this paper addresses one research question: What are the core characteristics that an ideal e-assessment system should have to successfully support higher education e-assessment? This paper will firstly approach e-assessment systems improvement and evaluation. The methods section ensues and precedes the description, analysis and discussion of the results. The paper concludes with an overview of its limitations and the expectations for future research ventures.

II. IMPROVING E-ASSESSMENT SYSTEMS

In the context of higher education, despite a growing acceptance of e-assessment [1], the COVID-19 pandemic period showed that the institutions lacked preparation in terms of a more widespread incorporation of e-assessment [15].

Research on e-assessment systems reveals a growing concern for the incorporation of more ample features, to address some of the challenges that are encountered when resorting to these systems and to widen the possibilities afforded by the systems. Iftikhar, et al. [11] propose an e-assessment system that addresses two core challenges of design: the communication of progress to the students and the need to maintain student motivation and engagement. The authors report on the development of the Learning Intelligent System (LIS), an e-assessment system focusing on personalised feedback, whose design was positively evaluated by the students. Personalisation was also a significant concern of the TeSLA (Adaptive Trust-based e-Assessment System for Learning) European project, although the focus was on security, through authentication. The system that is proposed by this project uses biometric instruments, such as facial and voice recognition and keystroke dynamics, and textual analysis resources, which include plagiarism detection and forensic analysis. Another important characteristic of this system is interoperability. It is implemented through a Learning Tools Interoperability (LTI) plugin, ensuring its integration with any virtual learning environment (VLE) [12].

The e-assessment system proposed by Hajjej, et al. [13], Cloud-AWAS, accounts for personalisation and interoperability and it is based on a cloud computing environment. The architecture of the system that the authors describe is based on cloud services. The cloud services are used to adapt the assessment activities to the profile of the students, which is obtained through their data. The development of this e-assessment system also accounted for the need for interoperability and it is, therefore, possible to integrate it into various learning management systems (LMS). The variety in the array of questions that an e-assessment system can support is an important element of its effectiveness. Attributing a grade and generating feedback for open design exercises, such as diagrams, brief essays or program code is a complex task for e-assessment systems and require a specific architecture. JACK, an e-assessment system, can be used in this type of e-assessment activities. It can be used not merely as a grading instrument for these exercises, but it is equally valuable in the provision of textual feedback to specifically assist the learners to improve their outcomes [14]. The JuxtaLearn system, described by Adams and Clough [16] was developed to support the creation of quizzes for assessment, based on pedagogical approaches. It was designed to support the e-assessment process in three phases, using specific instruments to assist teachers in the creation of the quizzes that are pedagogically sound; incorporating the quizzes into the students' personalised learning paths; and providing feedback both to the students and to the teachers to direct learning.

III. EFFICIENT E-ASSESSMENT SYSTEMS

The abundant offer of e-assessment systems can encumber the selection of the most appropriate system, by teachers. There is a lack of research in terms of e-assessment systems' evaluation. Solely a few studies have examined e-assessment systems from the perspective of their quality and essential characteristics. Chirumamilla and Sindre [3] study examined the key features of e-exams systems, but from the perspective of vendors and managers. Their findings emphasised functional features such as authoring and grading and non-functional features like usability, integrity, interoperability and security. Although this contribution makes a valuable addition to the current body of literature it excludes the opinions of the teachers. Singh and de Villiers [17] study focuses on the evaluation of e-assessment systems by proposing a framework composed of 11 categories, divided into two groups, functional and non-functional, and with 182 criteria. The categories, question editing, assessment strategy, test and response, test bank, question types, interface, security, compatibility, ease of use, robustness and technical support, offer a conceptual mapping of requirements. Despite its valuable contribution, this framework is limited to a specific type of system, multiple choice questions systems. In an effort to provide some structure and guidance to the evaluation of e-assessment systems, this paper appraises the framework proposed by Isaias, et al. [18] for the selection of efficient e-assessment systems, combining eight key categories of features: variety of assessment design options, scalability, security, accessibility and usability, feedback features, personalisation, financial cost and interoperability.

IV. METHODS

Based on this study's research question, a quantitative methodological approach was deemed more appropriate. This type of approach enables the assessment of theories through the examination of measurable variables. In terms of research design, this study resorted to survey research for its value in collecting quantitative data on the viewpoints of a particular population [19] and it was used in this research via the design of an online questionnaire. The use of an online questionnaire was justified by the fact that the population was geographically dispersed, the various advantages that it presents at the level data entry and storage and the accessibility to the responds [20]. Using convenience sampling [21] the respondents were selected from an international population of teachers and researchers, who were invited to participate for their expertise in the higher education sector. Convenience sampling has some limitations, but certain steps can minimise them, such as selecting as many participants as possible [22], which was performed in this research. The online questionnaire was divided into two sections. The first section was designed for the collection of data related to the demographic profile of the respondents and their experience with e-assessment systems. In the second section, the respondents were required to use an adapted Likert scale (1 to 5 ratings) to convey their level of agreement with the items that related to the proposed framework. Each item pertaining to the different elements of the framework was the result of an integrative literature review [23]. This literature review was equally the basis for the creation of the remaining questions in the questionnaire. The pilot questionnaire was sent to a small group of expert respondents who assessed its content, design and clarity. Based on their feedback, no changes were made. The final version was sent to the selected sample by email invitation through the SurveyMonkey platform.

The data analysis, in SPSS 20, had two stages. The first preliminary analysis comprised descriptive statistics, such as the calculation of frequencies, mean and standard deviation values, to portray the general opinion of the experts. The second step in the analysis consisted of a factor analysis of the Likert scale questions pertaining to the framework, in order to simplify and reduce the data to the most relevant items.

V. RESULTS

In total 231 complete responses to the questionnaire were considered valid for analysis.

A. Participants' profile

The sample was composed by 55% of male participants and 45% of female participants. With respect to their age, it was widely distributed: 3% were under 30; 43% were 30-50; 51% were 51-70, and 3% were over 70 years old. The questionnaire's online distribution to an international sample produced responses from 37 countries, such as UK, Germany, Italy, Greece, Portugal, Canada, USA and Australia.

The participants' professional profile was determined by 74% of teaching positions, namely professors (27%), associate professors (18%), senior lecturers (13%) and lecturers (10%). The remaining respondents held research related professions (14%) or specified other positions (11%), such as assistant dean, curriculum developer and e-assessment development manager.

Besides their professional profile, it was essential to determine their familiarity with e-assessment systems (figure 1).

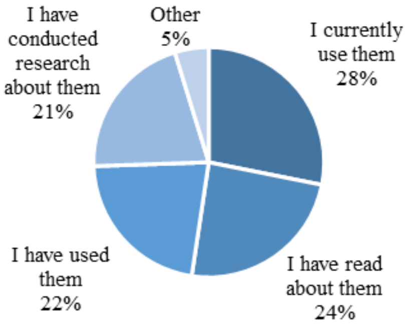


Fig. 1. Respondents' level of familiarity with e-assessment systems

In order to qualify to answer the remaining items on the questionnaire pertaining to the framework, the respondents had to, at least, have read about e-assessment systems, which all the participants had. As figure 1 illustrates, the majority of the sample has a considerable familiarity and an extensive experience with e-assessment systems, which speaks to the validity and adequacy of their contribution to this questionnaire and their evaluation of the framework.

B. Characteristics of efficient e-assessment systems

The last part of the questionnaire required the participants to assess each of the characteristics of the framework, by stating their agreement or disagreement with several related statements, using a Likert scale. All the characteristics of the framework were supported by the viewpoint of the respondents in general, as is illustrated in table 1 displaying the mean and standard deviation calculations.

TABLE I. MEAN AND STANDARD DEVIATION FOR ALL THE CHARACTERISTICS OF THE FRAMEWORK

Framework characteristics and items	Mean	SD
Variety of Assessment design options		
Have a variety of question edition tools (ex. grammar, spellcheck)	4.11	0.79
Provide teachers with different assessment instruments (ex. portfolios, surveys)	4.40	0.75
Allow the design of several question types	4.61	0.60
Incorporate authentic assessment tasks, for example via simulators and games	4.21	0.85
Allow the use of multiple assessment techniques (ex. peer-assessment, self-assessment)	4.35	0.78
Scalability		
Assists an institutional-wide implementation	4.07	0.76
Can be facilitated by automation	4.08	0.85
Allows the delivery of assessment to a higher number of students	4.34	0.71
Can be improved by the use of cloud computing solutions.	3.83	0.92
Enables the delivery of a growing number of assessments	4.07	0.84
Security		
Be required to have options to identify and avoid students' unauthorised behaviour	4.26	0.78
Benefit from the existence of features for the management of personal and assessment data (ex. safe storage, privacy, integrity)	4.32	0.69
Use IP address restriction options	3.64	1.07
Employ student authentication solutions (ex. Personal credentials, video, biometrics)	3.97	0.87
Have features for question randomisation and versioning	4.32	0.79
Be required to have options to restrict/interdict access to the internet/network during assessment activities	4.02	0.98
Accessibility and Usability		
Are conditioned by ease of use	4.22	0.73
Improve with the existence of help options	3.94	0.80
Benefit from the inclusion of a variety of features for promoting access (ex. font size and colour edition, audio transcriptions, subtitled videos)	4.13	0.72
Are enhanced by the incorporation of training functionalities	3.90	0.83
Require their compatibility with most operating systems and devices	4.45	0.68
Demand the provision of technical support	3.89	0.91
Feedback features		
Deliver feedback information to both students and teachers	4.53	0.66
Guarantee students' access to their previous results	4.28	0.82
Include options for the management of assessment data (ex. documentation, statistical analysis)	4.48	0.66
Provide students with an overall depiction of their peers' results	3.66	0.93
Employ automated grading	3.87	0.91
Be required to have mechanisms for answer acceptance (ex. dealing with misspelling, case sensitivity)	4.12	0.80
Personalisation		
Is a fundamental requirement of these systems	3.92	0.89
Can assist teachers to develop more suitable assessment activities through the inclusion of adaptive testing	4.19	0.74
Should include configurations to adapt them to the assessment needs of teachers and institutions	4.20	0.77
Is in great part assured by their ability to deliver adaptive assessment activities	3.83	0.89
Financial Cost		
It is essential that they are financially effective	4.06	0.84
It is better to resort to LMSs for e-assessment than to use specialised e-assessment systems	3.17	1.06
It is more important to select a system that is open source	3.50	1.03
LMSs should not be used for e-assessment activities because the features they offer are limited	2.78	1.00
A commercial system is preferable to an open source alternative, if the assessment design options are more advanced	2.94	1.06
Interoperability		
It is an ideal characteristic of these systems	4.13	0.69
It can be improved through the development of common standards	4.13	0.68
It can assist the integration with other systems and educational applications	4.19	0.67
It is important to assist the incorporation of different data sources	4.12	0.72

An overall analysis of the mean values for the different characteristics of the framework reveals its general validation by the sample of experts. The first element of the framework, variety of design options, registered agreement levels (combination of totally agree and agree ratings) from 81% to 96%. In addition, all the items had a mean of 4.11 or over, with the respondents highlighting the importance of being able to design several question types. In terms of scalability, the items agreement levels varied from 61% to 90% and the participants underlined the fact that it allows the delivery of assessment to a higher number of students. Although scalability had lower means, the values are still significant (M = 3.83 to 4.34) and the standard deviation remained inferior to 1 (SD = 0.71-0.92). With concern to security, its items gathered an agreement percentage from 72% to 90%, with the exception of IP restriction options (54%). The responses reflected varying opinions with regard to the limitation of IP addresses, with 33% of neutral ratings and 13% of disagreement (combination of totally disagree and disagree ratings). The participants underlined the existence of features for the management of personal and assessment data (ex. safe storage, privacy, integrity) and the inclusion of options that allow question randomisation and versioning. As the other elements of the framework, accessibility and usability were validated by an expressive majority of agreement levels (72% - 92%). The lower mean values for help options, training functionalities and technical support, can be explained by the significant levels of neutral ratings (between 20% and 23%). The fact that e-assessment systems should be compatible with most operating systems and devices was the item that the respondents highlighted as being more important.

Feedback is an integral part of e-assessment systems and the respondents clearly supported this argument in the questionnaire. All items were assigned agreement ratings between 58% and 96%. The provision of feedback to both students and teachers and the presence of options for assessment data management, were highlighted as the most relevant aspects of feedback. The aspect that received less agreement concerns the provision of an overall depiction of peers' results. Not only it had a high neutral score (30%), but also 11% of the participants disagreed with this proposition. Personalisation was deemed as an essential characteristic of e-assessment systems by the respondents, having attributed to it ratings of agreement ranging from 66% to 85%. Examining the mean values reveals the predominance of two items: the inclusion of configurations to adapt the systems to the needs of both teachers and institutions and the existence of adaptive testing. In addition, it is important to underline the fact that 29% of the respondents assigned a neutral rating to the item that states that personalisation is a fundamental requirement of e-assessment systems.

With concern to the financial cost of e-assessment systems, while 75% of the respondents agreed that the systems need to be financially effective, the extent to which they were willing to sacrifice advanced assessment options, for financial reasons, was unclear. Although 47% agreed that it is more significant to select an open source system, 39% were neutral and 13% disagreed. Also, when asked if a commercial system is preferable to an open source alternative, if the assessment design options are more advanced, there was only 29% of agreement, 39% of the responses were neutral and there was 31% of disagreement. Moreover, only 32% of the participants agreed that it is better to resort to LMSs for e-assessment than to use specialised e-assessment systems and solely 22% of the sample was in agreement with the fact that LMSs should not be used for e-assessment activities because the features they offer are limited. The final characteristic, interoperability, had the lowest disagreement rates, ranging from 0% to 0.4%. With respect to the ratings pertaining to agreement, interoperability registered percentages from 81% to 85%. This characteristic of e-assessment systems was also the one with less variability among the items, with a minor predominance of the item relating to interoperability's ability to assist the integration with other systems and educational applications.

Factor analysis

The questions pertaining to the framework, measured with a Likert scale were further analysed and the descriptive statistics was complemented with a factor analysis, which was used due to its ability to outline clusters of variables that provide an understanding of the elements of a group of variables and its capacity to define if the several measures under study are a product of the underlying variable [24]. Factor analysis assists researchers "in identifying and/or understanding the nature of the latent constructs underlying the variables of interest" [25]. In order to determine the viability of this analysis it was important to explore the factorability of the 41 items measured by the Likert scale. The Kaiser-Meyer-Olkin test was conducted and resulted in a value of 0.842, which is above the recommended 0.5 value [24] and the Bartlett's test of sphericity returned a 0.000 value, which means it is significant, as it must be lower than 0.05 [24] and that the data is not normally distributed. The communalities table was also used and showed that all the values were above 0.3, which indicated that all the items shared some common variance. The fact that in the anti-image correlation matrix all the diagonals were over 0.5 was equally supportive of including all items.

The factor analysis included all items, as per the abovementioned tests and criteria and it was performed using the Principal Component Analysis (PCA) extraction method and the Varimax orthogonal rotation. PCA is likely one of the most popular and old multivariate statistic techniques which aims to simplify and reduce data, by extracting only the most relevant information, and provide an analysis of the structure of the variables and observations [26]. The varimax is one of the most frequently used methods of orthogonal rotation and offers high quality interpretation results [27]. In the factor analysis the percentage of total variance was examined and based on a visual interpretation of the scree plot below, and on the eigenvalues (>1) of the items, 13 main components were extracted (figure 2).

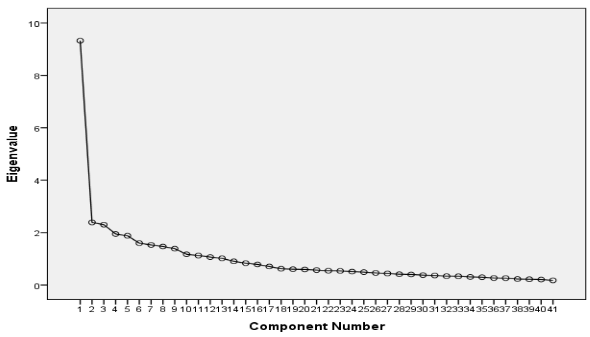


Fig. 2. Scree Plot for all items

The scree plot facilitates the visual detection of the factors that will be extracted for consideration. In examining the rotated component matrix table it was possible to interpret the extracted components by connecting them to the several items, using their factorial weight. Sorting the data by size provided a clear depiction of each component, being that the majority was associated with clear clusters of items:

- Component 1, which alone explained 23% of the total variance was connected to the interoperability items, all four items had high factor loadings, with a predominance of the item stating that interoperability is an ideal characteristic of e-assessment systems (0.817);
- Component 2 was associated with a cluster of all the items in the personalisation characteristic, with the highest factor loading attributed to the item "can assist teachers to develop more suitable assessment activities through the inclusion of adaptive testing" (0.811);
- Component 3 corresponded to the group of all items pertaining a variety of design options and was led by the item "incorporate authentic assessment tasks, for example via simulators and games" (0.819);
- Component 4 was linked to all the items related to security, with a highlight to the item "be required to have options to restrict/interdict access to the internet/network during assessment activities" (0.759);
- Component 5 gathered the items that compose the accessibility and usability element of the framework, where the item with the highest factor loading was "are enhanced by the incorporation of training functionalities" (0.717);
- Component 6 was linked to a cluster of three of the scalability items, where the item "can be facilitated by automation" was prevalent (0.779);
- Component 7 gathered a cluster of four items from feedback features, led by the item "guarantee students' access to their previous results" (0.743);
- Component 8 was connected to the remaining items for scalability, with the item "can be improved by the use of cloud computing solutions" registering the highest factor loading (0.734);
- Component 9 gathered items of different elements of the framework, but among them, the item with the highest factor loading was "demand the provision of technical support" (0.752), pertaining to accessibility and usability;
- Component 10 was connected to both financial cost and security, but had a prevalence of the item "it is better to resort to LMSs for e-assessment than to use specialised e-assessment systems". (-0.706), which belongs to the financial cost element;
- Component 11 was associated with two financial cost items, with the prevalence of the item "LMSs should not be used for e-assessment activities because the features they offer are limited" (0.870);
- Component 12 gathered three items from feedback features, from which the item "employ automated grading" (0.782) registered the highest factor loading;
- Component 13 was linked to two items of financial cost, with the predominance of the item "it is more important to select a system that is open source" (0.825).

Together, these 13 components explain 69% of the total variance. Also, all the eight elements of the framework were contemplated in these 13 factors, reiterating the importance of each of them as characteristics of efficient e-assessment systems. The elements of the framework which were more divided between the components were financial cost, followed by feedback features, scalability and accessibility and usability. In the preliminary statistical analysis presented in section 5.2, these elements of the framework showed more variability among its items.

VI. DISCUSSION

This paper intended to address one research question: what are the core characteristics that an ideal e-assessment system should have to successfully support higher education e-assessment? The analysis of the respondents' input highlighted the importance of each of the eight elements of the proposed framework. Variety of assessment systems was mainly important for the possibility of incorporating authentic assessment tasks, such as simulators and games. This underlines the significance of this type of e-assessment and the importance of harnessing the potential of technological instruments beyond their mere electronic reproduction of paper based assessment. According to the results of the factor analysis, scalability can benefit both from automation and the use of cloud computing solutions, as some developers are already incorporating in e-assessment systems [13]. These options facilitate the delivery of e-assessment activities, and account for and ensure that higher numbers of students or courses, or an increase in assessment frequency will still be viable in the system. It anticipates and addresses progression. For the security element, the most significant aspect was the requirement to have options to restrict/interdict access to the internet/network during assessment activities, underlying the remaining concern that electronic tools can be used to gain access to the solutions of the assessment activities illicitly. The preservation of the integrity of the assessment process is crucial. With respect to accessibility and usability the focus was placed on the integration of training functionalities and the provision of technical support, which corroborates previous findings [17]. The level of comfort with an-assessment system is key both for teachers, in the sense that it will greatly affect the type of e-assessment that they can create, and for the students, who need to focus on completing their assignments rather than to feel anxious about how to use the system.

As was posited by Singh and de Villiers [17] and Weir, et al. [10], the results also show that feedback features should employ automated grading and ensure that the students have access to their previous results. The provision of prompt feedback is one of the most significant benefits of using e-assessment, as it offers students insight into their responses and allows them to refer back to it to visualise their progress. Personalisation, in its turn, was highlighted for its capacity to support the teachers in the development of more suitable assessment activities through the inclusion of adaptive testing. Adapting learning to each of the students is, again, one of the possibilities that only the deployment of technology can make viable. With concern to financial cost, the importance of selecting a system that is open source became evident. Also, in terms of the deployment of LMSs for assessment, it was established that they should not be used for e-assessment activities because the features they offer are limited and that it is not better to resort to LMSs for e-assessment than to use specialised e-assessment systems. Finally, in term of interoperability, the respondents, in line with Hajjej, et al. [13] and Okada and Whitelock [12] describe it as an ideal characteristic of these systems, which is aligned with a continuous branching of learning to various environments and systems. As e-assessment becomes dispersed to several platforms and systems, it becomes evident that the communication between these different instruments is essential.

VII. CONCLUSION

E-assessment systems are determinant for the delivery of effective and valuable learning assessment and their characteristics can either narrow or widen the possibilities for developing innovative assessment strategies and activities. This study contributes to research with empirical evidence of some of the key features of e-assessment systems and to practice with a guide to assist both teachers and systems developers' decision-making. Despite the insight that the results provided, it is necessary to examine the limitations of this research. The sampling methods that were selected prevent the generalisation of these results. With regards to the use of an online questionnaire, while it represents various advantages, it can provide limited insight into certain aspects of the research. In this particular case, it failed to explain the reason behind certain choices, namely the high number of neutral responses associated with some of the items.

In future research ventures it is fundamental to complement this study with input deriving from qualitative data, namely semi-structured interviews. By engaging the experts in a more in-depth analysis of the elements of the proposed framework, important information can be added to justify the importance of each of the elements. Since, the use of e-assessment systems is associated with several challenges, it would be valuable in the future to examine the impediments of their implementation. Finally, as e-assessment systems impact other stakeholders, such as students and higher education institutions, their viewpoints should also be considered in forthcoming studies.

REFERENCES

[1] P. Miranda, P. Isaias, and S. Pifano, "E-assessment: tools and possibilities for electronic assessment in higher education," in *Proceedings of the 11th International Conference on Education and New Learning Technologies (EDULEARN19)*, ed Palma, Spain: IATED, 2019, pp. 7431-7438.

[2] M. Ullrich, M. Forell, C. Houy, P. Pfeiffer, S. Schüler, T. Stottrop, *et al.*, "Platform Architecture for the Diagram Assessment Domain," in *Software Engineering (Satellite Events), Lecture Notes in Informatics (LNI) 2021*, Bonn, 2021.

[3] A. Chirumamilla and G. Sindre, "E-exams in Norwegian higher education: Vendors and managers views on requirements in a digital ecosystem perspective," *Computers & Education,* vol. 172, p. 104263, 2021/10/01/ 2021.

[4] I. Guitart Hormigo, M. E. Rodríguez, and X. Baró, "Design and Implementation of Dashboards to Support Teachers Decision-Making Process in e-Assessment Systems," in *Engineering Data-Driven Adaptive Trust-based e-Assessment Systems: Challenges and Infrastructure Solutions*, D. Baneres, M. E. Rodríguez, and A. E. Guerrero-Roldán, Eds., ed Cham: Springer International Publishing, 2020, pp. 109-132.

[5] F. Bayrak, "Investigation of The Web-based Self-Assessment System Based on Assessment Analytics in Terms of Perceived Self-intervention," *Technology, Knowledge and Learning,* 2021/04/04 2021.

[6] M. Bearman, J. H. Nieminen, and R. Ajjawi, "Designing assessment in a digital world: an organising framework," *Assessment & Evaluation in Higher Education,* vol. 48, pp. 291-304, 2023.

[7] D. Vomvyras, A. Andreatos, and C. Douligeris, "Exam Wizard: A novel e-assessment system," in *4th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference (SEEDA-CECNSM)*, ed: IEEE, 2019, pp. 1-6.

[8] Z. Yan, "Unprecedented pandemic, unprecedented shift, and unprecedented opportunity," *Human Behavior and Emerging Technologies,* vol. 2, pp. 110-112, 2020.

[9] P. Isaias, P. Miranda, and S. Pifano, "Framing social media and web-based communities within the COVID-19 pandemic: enduring social isolation and subsequent deconfinement," *International Journal of Web Based Communities,* vol. 17, pp. 120-134, 2021.

[10] I. Weir, R. Gwynllyw, and K. Henderson, "A case study in the e-assessment of statistics for non-specialists," *Journal of University Teaching & Learning Practice,* vol. 18, p. 05, 2021.

[11] S. Iftikhar, A.-E. Guerrero-Roldán, E. Mor, and D. Bañeres, "User Experience Evaluation of an e-Assessment System," in *International Conference on Human-Computer Interaction*, 2020, pp. 77-91.

[12] A. Okada and D. Whitelock, "An Evaluation Methodology Applied to Trust-Based Adapted Systems for e-Assessment: Connecting Responsible Research and Innovation with a Human-Centred Design Approach," in *Engineering Data-Driven Adaptive Trust-based e-Assessment Systems*, ed: Springer, 2020, pp. 239-265.

[13] F. Hajjej, Y. B. Hlaoui, and L. J. B. Ayed, "Adapted E-Assessment System Based on Cloud Computing," in *IEEE 17th International Conference on Advanced Learning Technologies (ICALT)*, ed: IEEE, 2017, pp. 251-255.

[14] M. Striewe, "An architecture for modular grading and feedback generation for complex exercises," *Science of Computer Programming,* vol. 129, pp. 35-47, 2016/11/01/ 2016.

[15] C. St-Onge, K. Ouellet, S. Lakhal, T. Dubé, and M. Marceau, "COVID-19 as the tipping point for integrating e-assessment in higher education practices," *British Journal of Educational Technology,* vol. 53, pp. 349-366, 2022.

[16] A. Adams and G. Clough, "The e-assessment burger: supporting the before and after in e-assessment systems," *Interaction Design and Architecture (s),* vol. 25, pp. 39-57, 2015.

[17] U. G. Singh and M. R. de Villiers, "An evaluation framework and instrument for evaluating e-assessment tools," *The International Review of Research in Open and Distributed Learning,* vol. 18, 2017.

[18] P. Isaias, P. Miranda, and S. Pífano, "Framework for the analysis and comparison of e-assessment systems," in *ASCILITE 2017-Conference Proceedings-34th International Conference of Innovation, Practice and Research in the Use of Educational Technologies in Tertiary Education*, H. Partridge, K. Davis, and J. Thomas, Eds., ed: Australasian Society for Computers in Learning in Tertiary Education (ASCILITE), 2017, pp. 276-283.

[19] J. W. Creswell and J. D. Creswell, *Research design: Qualitative, quantitative, and mixed methods approaches*, 5th ed. Los Angeles: Sage, 2018.

[20] M. Nayak and K. Narayan, "Strengths and weaknesses of online surveys," *Technology,* vol. 6, pp. 0837-2405053138, 2019.

[21] P. J. Lavrakas, Ed., *Encyclopedia of Survey Research Methods*. Thousand Oaks, California: Sage Publications, 2008, p.^pp. Pages.

[22] S. J. Stratton, "Population research: convenience sampling strategies," *Prehospital and disaster Medicine,* vol. 36, pp. 373-374, 2021.

[23] H. Snyder, "Literature review as a research methodology: An overview and guidelines," *Journal of Business Research,* vol. 104, pp. 333-339, 2019/11/01/ 2019.

[24] A. Field, *Discovering statistics using IBM SPSS statistics*, 4th ed.: Sage, 2013.

[25] D. L. Bandalos and S. J. Finney, "Factor analysis: Exploratory and confirmatory," in *The reviewer's guide to quantitative methods in the social sciences*, ed: Routledge, 2018, pp. 98-122.

[26] H. Abdi and L. J. Williams, "Principal component analysis," *Wiley interdisciplinary reviews: computational statistics,* vol. 2, pp. 433-459, 2010.

[27] C. Acal, A. M. Aguilera, and M. Escabias, "New modeling approaches based on varimax rotation of functional principal components," *Mathematics,* vol. 8, p. 2085, 2020.

POSITIVE AND NEGATIVE FACTORS AFFECTING THE INITIATIVE FOR THE INCLUSION OF ICT IN THE SECONDARY EDUCATION CURRICULUM IN NAMIBE-ANGOLA

Santana Bunga
Provincial Office of Education, Youth and Sports of Namibe, Moçâmedes, Angola
Namibe, Angola
Ssantana2000@yahoo.com.br

***Abstract*—In Angola, the use of ICT in an educational context is no longer new, despite the limitations that have been registered in operational, strategic and pedagogical terms. In the present study, we sought to identify and understand the factors that enhance and hinder the effective inclusion of ICT in the curriculum of secondary schools in Namibe, from the perspective of the different local actors responsible for the implementation of the respective initiative. The qualitative and exploratory case study went through the auscultation of the respective actors and the analysis of the documents that govern the organization of the action at the level of the schools studied. From the analysis of the results, it was possible to assess that the aspects identified extrapolate the common vision around the theme, that is, they transcend a superficial and technocentric view, reduced to the existence or absence of technological resources and teacher training as factors that positively or negatively influence the success of the initiative in question. In this follow-up, the evidence points to the need for a scenario that also includes the will, delivery, commitment and awareness of all those involved in relation to the importance and benefits of ICT in the educational system.**

Keywords*—*ICT, Secondary education, promoting and inhibiting factors, Angola.

I. INTRODUCTION

ICT has emerged as a powerful resource in the teaching and learning process, facilitating the opening of doors and the construction of bridges (between the academic community, and educational institutions and strengthening relationships between the latter and the students' families), as well as such as expanding access to information, content, data, digital educational resources and providing access to training in a wide variety of educational contexts from early childhood to adulthood, anytime, anywhere. However, it is important to highlight that, technologies, in themselves, do not streamline the way in which schools and especially teachers work, given that what is at stake is not a simple update of material or technological resources at the level of school centres, but rather its reorganization according to new needs and new social challenges [1; 2].

The bibliographical research and the respective analysis carried out, within the scope of the development of this study, allowed us to verify that there are concerns in several quarters regarding the modernization of education through the inclusion of ICT in the education system, an experience that Angola has been experiencing in the recent years within the scope of commitments made in international forums in the field of Education [3; 4; 5; 6]. Focusing on the Angolan reality, it is important to highlight that it was within the scope of the curricular restructuring process of the current education system, approved in 2001, through Law 13/01, Basic Law of the Education and Teaching System (LBSEE), that the inclusion of ICT in the study plans of second cycle secondary schools was processed, with the aim of adapting the teaching and qualification of trainees to the demands of the new era of the information and knowledge society [7].

After almost two decades, it is important to study and understand the factors that positively and negatively influence the initiative to include ICT in an educational context, at the level of secondary schools in the province of Namibe. To this end, the following research question was raised: «What enabling factors and possible obstacles underlie the initiative that has been undertaken to include ICT in the curriculum of public secondary schools in Namibe?»

In the sections that follow, a synthetic approach is first presented regarding the enabling factors and obstacles that affect initiatives for the use of ICT in a school context. Next, the methodology adopted is characterized, the procedures relating to data collection and processing, and ends with the presentation of the results.

II. ANALYSIS OF THE ENABLING FACTORS AND OBSTACLES THAT AFFECT INITIATIVES FOR THE USE OF ICT IN THE SCHOOL CONTEXT

Despite the notable growth in the use of ICT at a social level, the analysis of the literature on the issue of inclusion processes and the use of the respective technologies in a formal learning context presents several factors that impact their successful integration in education, from that stand out: leadership, vision, planning, professional development and long-term sustainability.

Following this, [8, 9] point out that despite the large investments made to integrate technology in schools, the results have not been promising. In the opinion of [10, 11] the findings in question can be justified by the lack of a culture of change and innovation on the part of schools. In another dimension, the organization and the authors mentioned below add the lack of commitment, interest and motivation of the parties involved, as well as the lack of technical and pedagogical capacity, combined with the lack of monitoring and evaluation in the process of integrating ICT policies in education, as factors that contribute to the lack of impact on implemented initiatives [12; 13].

Furthermore, it should be noted that, in addition to the factors that can have a negative effect on initiatives for the inclusion and use of ICT in education, revealed by the authors mentioned above, it was also possible to infer in the respective studies that initiatives to integrate technologies in education that begin with an in- depth analysis of the basic needs for their development, are more likely to be effective, indicating, for example, the need to define the pedagogical objective before any technological tool to support the teaching and learning process; the existence of a properly equipped ICT infrastructure; the commitment and adherence of teachers to the initiative aimed at transforming education through ICT; the training and continuous professional development of teachers, as factors that positively affect the inclusion and innovative use of technologies in education.

III. RESEARCH METHODOLOGY

The present study fits into the interpretative paradigm, of a qualitative nature. In strategic terms, we opted for an exploratory case study [14; 15].

Regarding the participants, it is important to note that, for ethical reasons, in the present study we sought to safeguard not only the privacy of the respective participating subjects, but also the institutions in which the research work carried out took place, through codes, that is, E, for participants, and A for schools. In this context, it should be noted that 11 members from different institutions in the education sector at the province level participated in the study, selected according to the convenience sampling criterion, not probabilistic [16].

As for data collection techniques, we opted for documentary analysis (of documents such as Educational Project and Annual Activity Plan), and semi-directive face-to-face interviews with those responsible for the integration of ICT at the level of the schools studied [7].

To decipher the meanings contained in the material collected from both sources, we opted for the technique of content analysis by category. Following this, once the categories were defined, that is, after several reading sessions, from floating to detailed reading [17; 18], themes related to the categories were selected, as registration units. The development of the exercise in question allowed both the systematization of interview analysis data and document analysis.

IV. PRESENTATION, ANALYSIS, AND TRIANGULATION OF RESULTS

The presentation of the cross-analysis of the results of the present study involved the assessment of some documents mentioned above, whose results are presented a priori with a view to better understanding the case studied and following the order of the defined categories and subcategories of analysis.

Category 1 – school guidance plan

In this category, we sought to analyze the agendas of activities that have been outlined for the inclusion and use of ICT at the level of the schools studied. For this purpose, three subcategories of analysis were defined:

Subcategory a – installations in general

In terms of facilities, all schools indicate, in their respective educational projects, that they have, in addition to spaces essential for their normal functioning (offices for management staff, secretariats, teachers' room and classrooms, among other facilities), a computer room, as in schools A, B, E, F, G and H. In relation to schools C and D, the number of computer rooms/laboratories varies between four and six.

The respective evidence validates the data obtained in the analysis of the interviews carried out. Below are the textual units of some interviewed elements.

> "It is important to note that the school was opened without a computer laboratory; As such, in order to deal with the respective situation, the respective computer room was improvised […]" (E4).

"The school contains more than 10 classrooms, five computer laboratories […]" (E7).

"[…] We have a room with practically no furniture and only one computer" (E9).

Regarding facilities, the evidence from the cross-analysis reveals the existence of asymmetries, as certain schools report that they have more than one room/laboratory, while others do not even have a properly equipped room.

Subcategory b – technological equipment

Regarding the conditions in terms of IT equipment, none of the educational projects of the different schools detail the number of stocks. In this regard, the narratives selected within the scope of the cross-analysis are presented:

> "[…] The institution operates with a computer laboratory, which we can consider poorly equipped due to the lack of replacement and updating of the respective equipment, taking into account its useful life: it is a "God help us!". […]" (E5).

> "[…] Regarding the existence of equipment, we can say that the rooms are reasonably equipped […]" (E7).

"In terms of the computer room and related equipment, we have some difficulties" (E10).

"[…] Our computer room has only five operational computers […]" (E11).

From reading the cross-analysis regarding the technological equipment existing in the IT rooms/laboratories, the evidence reveals that the institutions in question lack equipment and renovation of the IT park.

Subcategory c – teacher training

Regarding training actions (Table 1), except for school C, the institutions do not specifically specify, in the annual activity plans, in which follow-up of pedagogical intervention the action agendas/guidelines for the training of their respective teachers are directed.

TABLE 1 – TRAINING ACTIVITIES OUTLINED BY DIFFERENT SCHOOLS

School	Training/qualification activities	OBS
A	Usual pedagogical training of teachers from the Economic and Social Development Coordination	
B	Conducting Pedagogical Training (developing skills, habits and planning skills and methodological execution of programs)	
C	Internal and external training, with a view to improving the technical, practical, and pedagogical capacity of professionals assigned to the institution	
D	Holding training seminar for teachers	
E	Pedagogical training (pedagogical aggregation)	
F	Seminar and pedagogical days for all teachers (refreshing teachers' knowledge, with a view to the new academic year)	
G		No registre
H	Refreshment seminar (dosing the contents)	

Source: Activity plan for schools A, B, C, D, E, F, G and H

The cross-analysis of the data obtained in the interviews reveals the following information:

> "In terms of training, in past years, the Ministry sent teachers abroad for this purpose, a process that was paralyzed after the financial crisis. Internally, the school has carried out the respective actions during pedagogical breaks" (E6).

"As for human resources, in the area of ICT, the school still lacks staff, […]" (E8).

> "In terms of training staff in the ICT area, we have a specialist, that is, a teacher trained in computer engineering. The rest are adapted (teachers who have a computer course). It is important to say that there have been training seminars given by IT teachers […]" (E11).

The assessment of the evidence from the cross-analysis regarding teacher training actions reveals that there is little investment in teacher training actions, leading to raising their level of skills in the use of technologies in classes, which is justified by the financial crisis that the country has been experiencing since 2014.

Category 2 – Enhancing factors and obstacles that affect the impact of initiatives for the use of ICT in the school context.

Regarding the category in question, in the present study, the participants admit that there is, according to their experiences, a set of factors that have positively and negatively influenced the initiative in question and which were divided into two subcategories of analysis:

Subcategory D – Enhancing factors

In the category referring to the factors promoting this integration, we report the opinions of interviewee E5, who indicates "the desire to do so, that is, compliance with the outlined policies", and E8: "the delivery and commitment of all those involved in the respective process". A set of convergent opinions was also recorded regarding this, from which we present the selected textual units:

> "In terms of factors that can promote the effective integration of ICT, at the level of II CES schools, we can first mention: awareness of their importance in the school context on the part of actors in the teaching and learning process; the commitment of everyone and especially political decision-makers in the respective process [...]" (E1).

> "Among the factors that promote better integration of ICT in the study plans of II CES schools, there may be greater awareness regarding their importance and benefits in the teaching and learning process" (E3).

> "The existence of legislation and regulations as a basis for developing work; the existence of financial support; the existence of investment in training and continuous training of human resources, as well as investment in infrastructure and its maintenance" (E6).

Subcategory E – Inhibiting factors

Regarding the subcategory in question, the inhibiting factors, that is, that make it difficult to integrate ICT into study plans, in addition to the consensual aspects indicated by the majority of participants, which have been presented as the "Achilles heel" (lack of initial and continuous training of teachers; lack of material conditions and financial availability; the existence of schools that only administer theoretical classes due to a lack of computers; as well as the disappearance of the item for continuous maintenance and replacement of computer equipment and Internet service in the institution). "Resistance to change on the part of teachers" was mentioned; fear of assuming that they do not know or do not master the use of new technologies" (E1), as well as "the organization of the school to be able to respond to the demands in terms of integrating them into the teaching and learning process" (E8). Below, we present the selected textual units:

"[...] the lack of commitment from all actors in the process" (E2).

> "[...] Lack of coherence between what is idealized and the respective practices for implementing ICT in schools; the high cost of technological means" (E5).

From the appreciation of the promoting and inhibiting factors that affect initiatives to include ICT in education, it is possible to verify that the aspects mentioned transcend a superficial and technocentric view – reduced to the existence or absence of technological resources and teacher training as factors that positively influence/ negatively the success/failure of the policy in question.

V. CONCLUSIONS

In summary, with this study we sought to identify and understand the enabling factors and possible obstacles that affect the initiative that has been undertaken to include ICT in the curriculum of public secondary schools in the province of Namibe, resulting from the restructuring of secondary education study plans in Angola. Regarding the results, the evidence that emerged from the cross-analysis reveals that the respective initiative aimed to provide secondary education institutions with conditions for the inclusion of ICT in the curriculum of their schools, namely: the commitment to continuous teacher training for the use of ICT in a formal learning context; creation/construction and equipping of ICT infrastructures in schools.

It is important to clarify that the actions highlighted above were not transversal, as, in some schools, no investments were made to include ICT in study plans. The finding in question indicates the existence of asymmetries between the schools studied, regarding their organization and transformation to include ICT in the study plans, and, certainly, positions the schools in different development plans of the respective initiative, aimed at dynamizing and enriching the teaching and learning process and develop in students the skills necessary for the new era of the knowledge society.

the appreciation of the promoting and inhibiting factors that affect initiatives to include ICT in education at the level of the studied context, it was possible to verify that the identified aspects transcend a superficial and technocentric vision – reduced to the existence or absence of technological resources and teacher training as factors that positively/negatively influence the success/failure of the policy in question. The evidence points to the need for a scenario that includes, among others, the will, delivery, commitment and awareness of all those involved in relation to the importance and benefits of ICT in the educational system, as aspects that can influence positively the success of the respective initiative. Factors opposite to those indicated above are mentioned as obstacles that make the effective inclusion of ICT in an educational context unfeasible, to which the need for serious and continuous investment in the training of human resources and in infrastructure and its maintenance is added.

VI. RECOMMENDATIONS/SUGGESTIONS

From the above, it is important to emphasize that, in initiatives of this magnitude, with the mobilization of large resources, both human, material, and financial, it is imperative to develop consistent projects and programs, that is, properly designed and put into practice with will, determination and rigour so that there is a greater probability of the results being satisfactory.

REFERENCES

[1] UNESCO end OEI, Diretrizes de políticas da UNESCO para a aprendizagem móvel. Brasil: UNESCO, 2014.

[2] J. Ponte, end L. Serrazina, As Novas Tecnologias na Formação Inicial de Professores Departamento de Avaliação Prospectiva e Planeamento. Lisboa: Ministério da Educação, 1998.

[3] UNESCO, Educação para todos: O compromisso de Dakar. Brasília: CONSED, 2001.

[4] UNESCO. Education 2030: Incheon Declaration and framework for action towards inclusive and equitable quality education and lifelong learning for all. Paris: UNESCO, 2016.

[5] ONU, Transformando Nosso Mundo: A Agenda 2030 para o Desenvolvimento Sustentável. Nova York: Organização das Nações Unidas, 2015.

[6] Africa Union, Continental education strategy for Africa 2016 – 2025. Addis Ababa: African Union Headquarters, 2016.

[7] S. P. S. Bunga, Política para integração das TIC em no currículo em Angola. Um estudo nas escolas públicas do II ciclo do ensino do ensino secundário do Namibe. Tese de doutoramento. Aveiro: Universidade de Aveiro, 2020.

[8] E. F. Fagundes, M. F. F. Arruda, M. M. R. L. Moraes, and K. C. Moreira, As dificuldades e limitações encontradas pelos docentes no uso das TIC no âmbito da educação pública. VI Congresso Internacional das Licenciaturas, COINTER – PDVL 2019.

[9] S. Timotheou, O. Milou, Y. Dimitriadis, S. V. Sobrino, N. Giannoutsou, R. Cachia, A. M. Monés, end A. Loannou, “Impacts of digital Technologies on education and factors influencing schools´ digital capacity and transformation: A literature review”. Education and Information Technologies, Vol 28, pp. 6695-6726, 2023.

[10] F. E. S. Oliveira, TIC´S na Educação: métodos, dificuldades de inserção e sua importância no aspecto didático. Monografia de especialização. Madeira: Universidade Tecnológica Federal do Paraná, 2020.

[11] L. B. Samussone, S. F. T. Siveira, A. C. B. Júnior, end D. C. S. Alexandre, “Fatores condicionantes para a tendência de uso de tecnologias de informação e comunicação no ensino superior em Moçambique”. Sociedade de Pesquia e Desenvolvimento, Vol. 10, (6) e56910616053, 2021.

[12] Commonwealth, ICT integration in education (This e- Discussion conducted by The Commonwealth Education Hub as a precursor to the ICT Integration in Education Roundtable at 19 CCEM, Bahamas june 2015).

[13] J. Conrads, M. Rasmussen, N. Winters, A. Geniet, end L. Langer, Digital education policies in Europe and beyond: Key design principles for more effective policies. EUR 29000 was EN. Luxembourg: Publications Office of the European Union, 2017.

[14] J. W. Creswell, Investigação qualitativa e projeto de pesquisa, 3rd ed., São Paulo: Penso Editora Ltda, 2014.

[16] J. Vilelas, Investigação – O processo de construção do conhecimento. (3ª ed.). Lisboa: Edições Sílabo, Lda., 2020.

[15] R. K. Yin, Estudo de caso – Planeamento e métodos 5rd Ed., São Paulo: Bookman Editora, Ltda, 2015.

[17] L. Bardin, Análise de conteúdo, 4rd ed., Lisboa: Edições 70, 2016

[18] J. Amado, Investigação qualitativa em educação, 3rd ed., Coimbra: Imprensa da Universidade de Coimbra, 2017.

THE USE OF IMMERSIVE VIRTUAL REALITY IN EDUCATIONAL PRACTICES IN HIGHER EDUCATION: A SYSTEMATIC REVIEW

1st Daniela Rocha Bicalho
Research and Development Unit in Education and Training (UIDEF)
Institute of Education, University of Lisbon
Lisboa, Portugal
danielabicalho@campus.ul.pt

2nd João Manuel Nunes Piedade
Research and Development Unit in Education and Training (UIDEF)
Institute of Education, University of Lisbon
Lisboa, Portugal
ORCID 0000-0002-4118-397X

3rd João Filipe de Lacerda Matos
Center for Interdisciplinary Studies in Education and Development
Lusófona University of Humanities and Technologies
Lisboa, Portugal
ORCID 0000-0002-5546-5257

Abstract — **This study aims to contribute to the expansion of discussions and considerations on the use of immersive technologies in an educational context. With the advancement of information technologies, immersive technologies, especially Virtual Reality (VR), can be important allies in the digital transformation of education. The purpose of this study is to understand how immersive virtual reality contributes to student learning in higher education. The objective is to analyse how learning occurs in immersive environments, their characteristics, benefits, and limitations. A systematic literature review methodology was adopted following the PRISMA protocol. The selection process of academic publications was based on an initial set of 764 articles, resulting from a search of the EBSCO database, published between 2017 and 2022. Three stages of article selection were carried out, resulting in the selection of 39 publications for analysis. The results show that the number of publications investigating empirical experiences has increased in recent years. Virtual Reality enables the creation of immersive virtual environments in which students can actively interact and explore. These simulated environments offer students the opportunity to experience authentic situations and apply their knowledge in a practical way.**

***Keywords* — empirical experiences, higher education, immersive environments, student learning, virtual reality**

I. INTRODUCTION

Digitalization and connectivity are causing changes in society and certainly in education, requiring the construction of new learning scenarios with multiple accesses to information, new applications and devices, the expansion of quality content for digital media, and the expansion of learning opportunities through the implementation of realistic and interactive environments. In the literature, technologies such as virtual reality, augmented reality and mixed reality are discussed under the term "Extended Reality (XR)". Due to its potential contribution to education, the focus of this study is on Virtual Reality (VR).

"Virtual reality technology is the integration of artificial intelligence technology, multimedia technology, computer graphics technology and computer network technology and developed into a new computer human-computer interaction technology, users can experience the three-dimensional virtual environment computer-generated , and naturally make a real-time interaction with virtual environment from visual, auditory and even tactile and taste, obtaining the similar operating experience with real-world" [1].

Virtual Reality technology enables the creation of a simulated digital environment that allows for more dynamic interaction with content through immersion. Makransky and Lilleholt [2] indicate that VR is a way to simulate or replicate an environment. There are several different VR systems, such as: (i) CAVE (Cave Automatic Virtual Environment), which uses projection technology to display 3D images within a large enclosed space; (ii) HMD (Head Mounted Display), which consists of an optical display in front of each eye, worn on the head or as part of a helmet, commonly referred to as VR goggles, that displays a virtual environment; and (iii) VR desktop, where the user interacts with a three-dimensional virtual environment displayed on a computer monitor using a keyboard, mouse, or joystick. Virtual environments that effectively exclude physical reality can be characterized as immersive VR [2]. On the other hand, desktop VR systems that have little or no ability to exclude physical reality can be characterized as non-immersive VR. This article will focus specifically on immersive VR that uses mobile VR (e.g., Google Cardboard, Samsung Gear), high-end HMDs (e.g., Oculus Rift, HTC Vive), and enhanced VR (e.g., a combination of HMDs with data gloves or bodysuits) as devices.

It is plausible to see in immersive environments a great potential to contribute to education by expanding the pedagogical space and time, in addition to increasing the dialogue between teacher and student. "Virtual reality (VR) technology has been widely used to create situated and realistic learning contexts that learners cannot easily access" [3]. It is also added that "Immersive Virtual Reality (IVR) systems offer several learning affordances, that is, characteristics that can

Doctoral Scholarship Reference 2022.11515.BD

elicit learning behaviors promoting learning outcomes in educational contexts" [4].

It is also important to emphasize, as cited by Sanchez-Sepulveda *et al* [5], that students seek to learn in different formats, want to create, use tools of their time, make decisions, share opinions, are interested in relevant learning and connected to reality.

The systematic review of the literature was adopted as the research methodology to analyse the ways in which learning occurs in immersive virtual environments and to ascertain the potential of Virtual Reality in learning experiences in a curricular context to answer the question: How does the use of virtual reality contribute to student learning in higher education?

This article is organized to detail the procedures in relation to the methodology adopted, describe the eligibility criteria, present general information about the 39 studies that make up the corpus of analysis, report some educational experiences that use immersive VR in a curricular context, and end with the conclusions.

II. Methodology

The aim of this systematic review was to perceive the use of VR technology in the educational field and to analyze the ways in which learning takes place in immersive virtual environments, their characteristics, advantages, and limitations.

The focus of the review is on learning experiences that make use of immersive virtual reality technology and that are developed in a curricular context in higher education. And the guiding questions are as follows: How has the publication on the use of immersive virtual reality in educational practices evolved between 2017 and 2022? In which academic fields of higher education have empirical studies with immersive virtual reality been conducted? How can virtual reality contribute to student learning in higher education? What are the limitations and challenges associated with the use of immersive virtual reality in educational practice?

A systematic review provides an overview of pre-existing knowledge about a phenomenon, subject or topic using appropriate and explicit methods [6]. The process of this systematic review was outlined by the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model [7], which, through its systematic methods, helps to identify, select and critically appraise the scientific production related to a given theme.

While recognizing that the use of multiple databases in a systematic review broadens the scope of the research, we chose to use a single multidisciplinary search platform that aggregates a large collection of academic periodicals and covers various fields of knowledge, EBSCOHost. The choice of this database was based on its ease of use, familiarity with the platform, and economy of effort in combining different search strategies when using multiple databases, which contributed to the efficiency and consistency of the specific search criteria used, which are described in detail throughout the text.

The starting point was a search for academic productions on the EBSCOhost platform, which includes the following databases: Education Source, Educational Resource Information Center (ERIC), PsycINFO, Psychology & Behavioral Sciences Collection, PsycARTICLES, Academic Search Complete, Library, Information Science & Technology Abstracts (LISTA), eBook Collection (EBSCOhost), and OpenDissertations. The search equation [a] is constructed by combining the Boolean operators with the keywords: "Virtual Reality", and "Education, Learning, and Training" in the English language, using the term "Virtual Reality" in quotation marks to identify the technology, excluding the use of the term "virtual" in isolation. The following filters and restrictions are included in the search: search fields: title, keywords, and abstract; text: full-text, open access, and peer-reviewed; publication period from 2017/08/01 a 2022/07/31.

Once the studies have been collected, it is necessary, as suggested by Kerres and Bedenlier [6], to develop rules about which studies will be selected for review. The selection criteria, which can be referred to as inclusion and exclusion criteria, are shaped by the research question. Thus, the inclusion criterion is defined as research with an empirical dimension on the use of virtual reality in higher education in a curricular context.

Fig. 1 illustrates the process of identification and selection of eligible articles according to the PRISMA model [7] .This methodological approach aims to ensure transparency in the selection process.

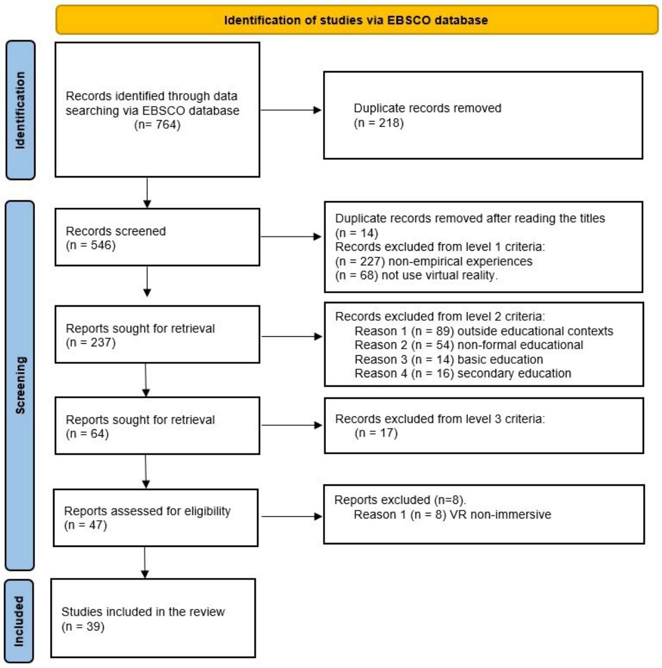


Fig. 1 PRISMA flow diagram of the systematic review process (adapted from Page *et al* [7])

[a] Search equation: [TI (("virtual reality" AND (education OR learning OR formation))) OR AB (("virtual reality" AND (education OR learning OR formation))) OR SU (("virtual reality" AND (education OR learning OR formation)))].

A total of 764 articles were identified and 218 duplicates were removed. The remaining 546 studies were catalogued by title, author, source, year, publication type, abstract, link, and database.

By reading the abstracts and, when necessary, consulting the methodological process, it was tried to identify investigations with empirical experience related to the use of virtual reality, identified as criterion 1. We identified 14 duplicate publications that were excluded, 227 articles that do not use empirical data, and 68 empirical publications that do not use VR technology in research.

Following the decision for the selection of articles, through the reading of the methodological process, we intend to verify the educational experiences in higher education, defined as criterion 2. The application of criterion 2 excludes from the 237 studies: (i) 89 publications from outside educational institutions, (ii) 54 from non-formal educational institutions, (iii) 14 from primary education, and (iv) 16 from secondary education.

There are 64 studies developed in higher education to apply criterion 3. Criterion 3 identifies experiences that are developed in a curricular context, where activities and practices are planned within the context of an educational curriculum and are applied for the purpose of enhancing student learning. Then, 17 studies that did not meet this criterion were excluded.

With 47 publications remaining to be assessed as eligible, it was identified that 8 studies did not use immersive virtual reality and were then excluded.

After applying the eligibility criteria, a set of 39 studies was selected to form the empirical material upon which the current systematic review presented in this paper is based.

The following section provides an overview of the eligible studies included in the review. It presents general information about the selected studies, including their characteristics and relevant findings, and describes some educational practices, answering the questions that guide this review.

III. Descriptive Results

As descriptive results about the corpus of analysis (n=39), the general information elaborated refers to the year of publication of the selected studies, the type of methodology adopted in each research, the country in which each study was developed, and the academic journals in which these studies were published. These details provide an overview of the characteristics of the eligible studies.

The increase in publications in 2020 and 2021 is highlighted in Fig. 2, which shows the number of publications between 2018 and 2022 according to the eligibility criteria of this review. The decrease in the year 2022 may be related to the period of the search for articles (until 31/07/2022), it is expected that the empirical debate on the subject will continue to be expanded.

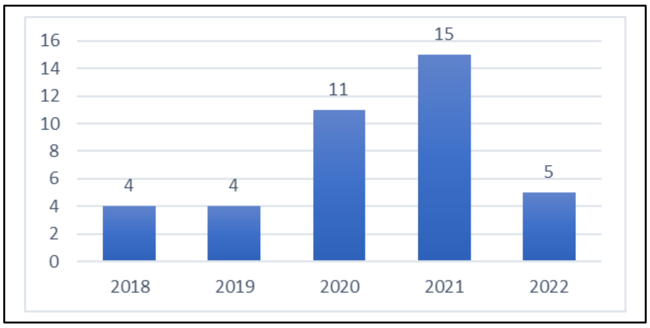


Fig- 2. Number of eligible articles published per year.

Regarding the type of methodology adopted, it is understandable that many studies use quantitative methods due to the exclusion of theoretical experiences and those that did not investigate empirical experiences. Of the eligible studies, 74% (n=29) use quantitative methods, 13% (n=5) use mixed methods, and 13% (n=5) use qualitative methods.

The studies were conducted in 14 countries. It is notable that 30% (n=12) of these studies were conducted in various regions of the United States, followed by China and the United Kingdom, each with 13% (n=5). Together, these three countries accounted for 56% of the publications analysed. See Figure 3, which shows the countries in which educational practices occur according to the eligibility criteria for articles included in this review.

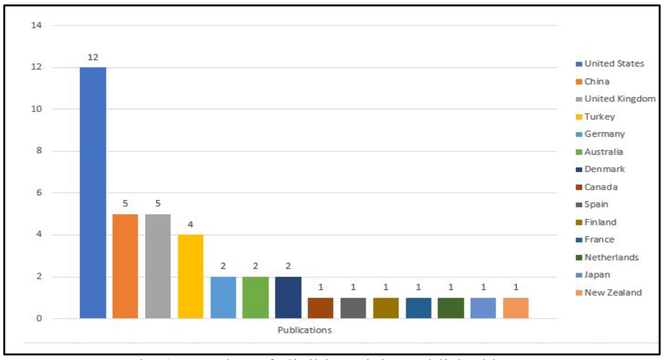


Fig. 3. Number of eligible articles published by country.

The academic journals with the highest number of publications meeting the criteria of this review are the British Journal of Educational Technology and Educational Technology Research & Development, which together account for 30% of the eligible publications, with 20% (n=8) and 10% (n=4), respectively.

In the educational practices reported in the selected articles, it is evident that immersive virtual reality "offer a novel virtual learning experience, where the virtual world provide personal viewing inside VR, thereby offering a sense of immersion during learning" [3]. VR offers the possibility to create simulations, that is, "interactive digital learning environments that mimic a real-life process or situation" [8].

Some studies have examined the development of public presentation skills through the use of simulations of real virtual worlds. McFaul and FitzGerald [9] used a virtual environment in a legal education program in which students interact with avatars representing audience members. These avatars respond to students' presentations with recorded questions, simulating a realistic interaction. This approach allows students to practice answering questions, dealing with challenges, and honing their communication skills in front of a virtual audience [9].

In the study by McGovern, Moreira, and Luna-Nevarez [10], a group of marketing students had the opportunity to practice body expression, eye contact, and use of gestures during their presentations and to receive feedback from the activity, allowing the students to make adjustments and improve their communication skills.

In the field of teacher education, VR has proven useful in the transition to teaching practice through classroom simulations that help future educators cope with anxiety and the initial challenge of managing a classroom [11]. It can also help manage student behavior, as in Chen's study [12], where participants interacted in an immersive learning environment with avatars representing students who exhibited challenging behaviors such as sleeping in the classroom, disrupting others, and using cell phones. Participants were instructed to teach the prepared material when dealing with these challenging behaviors. This experience allowed for the application of behavior management strategies, decision making, and problem solving [12].

There are also references that describe simulations of care in clinical practice in psychology [13] and social work [14] that provide students with access to experiences that may be difficult, dangerous, or costly in real life.

Another relevant aspect is the capability of VR technology to promote virtual visits to historical sites, museums, exhibitions, and cultural environments in an immersive way. A group of students from China and Uzbekistan learned about the cultures and traditions of their foreign partners through 360-degree videos and were able to summarize, explain, compare, and contrast the information they learned [15].

VR applications have also been used for architectural visualization in educational settings. This has been described in some studies [5], [16]–[19].

In addition, "the use of VR can encourage students to improve their analytical skills, such as collecting and analyzing data, writing computer programs, or making complex decisions" [20]. Through hands-on applications and conducting experiments, the technology has been used to teach and enable students to identify, analyze, and solve problems in various fields such as: robotics [21], electrical circuits [3], biology [22], and chemistry [23], [24].

The literature addresses the existence of common problems for users related to physical symptoms, such as nausea and dizziness [2], [20]. And also difficulties related to the technology itself, such as the quality and resolution of the screen, computational problems that occur during the experiments, and the cost of the equipment [20].

The study by McFaul and FitzGerald [9] portrays a low adherence of distance legal education students to carry out the immersive experience. The highlighted barriers are: (i) students did not realize that the software had enough value to invest time in using it; (ii) lack of student engagement, which underscores the importance of carefully integrating technology into learning objectives; (iii) lack of confidence or anxiety in dealing with new technologies; (iv) problems with the functionalities and quality of the application, which indicate the need for investment in developing technologies suitable for the purpose of the activity [9].

Limitations of the experiments reported in some studies include: (i) the short duration [13]; (ii) the small sample size [2], [25]; (iii) the reduced number of interactions with participants [13]; the difficulty of solving technical problems of access and use [25]. These facts corroborate the study conducted by Radianti, Majchrzak, Fromm and Wohlgenannt [20], which shows that the technologies discussed in most of the articles analyzed are still at an experimental stage. Their implementation is not systematic or based on best practices.

Despite the existing barriers, it is recognized that virtual reality technology contributes to the learning process by providing authentic and realistic simulated experiences that allow students to apply their knowledge in practice.

IV. Conclusions

Several systematic reviews [2], [4], [20], [26], [27] address immersive Virtual Reality in an educational context, highlighting the importance of understanding the use of this technology in educational practice. This study contributes to the debate on the use of Virtual Reality in Education, bringing information on a set of practical experiences in a curricular context in higher education.

It is possible to observe that the use of immersive virtual reality in practical experiences has demonstrated the technology's ability to create three-dimensional virtual environments that promote enriching learning experiences for students.

The results of the review indicate that: (i) there is an increase in the number of publications investigating empirical experiences using VR technology in recent years, which indicates the interest of universities in using immersive environments in educational practices; (ii) universities and academic institutions in the United States are excelling in educational practices that use virtual reality in the context of the curriculum.; (iii) the technology has proven to be a versatile and promising educational tool, that helps develop competencies, understand academic content in various fields of knowledge, improve presentation skills, and train complex practical situations; providing students with the opportunity to experience authentic situations and apply their knowledge in a practical way; (iv) the barriers to the implementation of technology in educational practices range from the cost of equipment, the lack of quality in software, and the apprehension of students and teachers to use the technology; and the limitations of the experiments demonstrate the immaturity of the use of technology in an educational context.

The study highlights that the integration of VR technology in education still faces significant challenges. It is important to reiterate that, as pointed out by Slater and Sanchez-Vives [28], "More affordable systems will facilitate not only the reach to final consumers but also to more developers and research groups, resulting in a much wider range of applications and generation of content for VR that will emerge in the near future." [28] This will facilitate the use of the technology in an educational context, through applications with higher quality and lower cost.

ACKNOWLEDGMENT

This work is funded by Portuguese National Funds through FCT - Foundation for Science and Technology, I.P., under the Doctoral Scholarship reference 2022.11515.BD.

REFERENCES

[1] F. Wu, Z. Liu, J. Wang, and Y. Zhao, "Establishment virtual maintenance environment based on VIRTOOLS to effectively enhance the sense of immersion of teaching equipment," in *Proceedings of the 2015 International Conference on Education Technology, Management and Humanities Science*, 2015, vol. 27.

[2] G. Makransky and L. Lilleholt, "A structural equation modeling investigation of the emotional value of immersive virtual reality in education," *Educ. Technol. Res. Dev.*, vol. 66, no. 5, pp. 1141–1164, 2018.

[3] B. Wu, X. Yu, and X. Gu, "Effectiveness of immersive virtual reality using head-mounted displays on learning performance: A meta-analysis," vol. 51, no. 6, pp. 1991–2006, 2020.

[4] A. F. Di Natale, C. Repetto, G. Riva, and D. Villani, "Immersive virtual reality in K-12 and higher education: A 10-year systematic review of empirical research," *Br. J. Educ. Technol.*, vol. 51, no. 6, pp. 2006– 2033, 2020.

[5] M. V. Sanchez-Sepulveda *et al.*, "Evaluation of an interactive educational system in urban knowledge acquisition and representation based on students' profiles," *Expert Syst.*, vol. 37, no. 5, Oct. 2020.

[6] M. Kerres and S. Bedenlier, *Systematic Reviews in Educational Research*. 2020.

[7] M. J. Page *et al.*, "The PRISMA 2020 statement: an updated guideline for reporting systematic reviews," *BMJ*, p. n71, Mar. 2021.

[8] Z. Merchant, E. T. Goetz, L. Cifuentes, W. Keeney-kennicutt, and J. Davis, "Computers & Education Effectiveness of virtual reality-based instruction on students ' learning outcomes in K-12 and higher education : A meta-analysis," *Comput. Educ.*, vol. 70, pp. 29–40, 2014.

[9] H. McFaul and E. FitzGerald, "A realist evaluation of student use of a virtual reality smartphone application in undergraduate legal education," *Br. J. Educ. Technol.*, vol. 51, no. 2, pp. 572–589, 2020.

[10] E. McGovern, G. Moreira, and C. Luna-Nevarez, "An application of virtual reality in education: Can this technology enhance the quality of students' learning experience?," *J. Educ. Bus.*, vol. 95, no. 7, pp. 490– 496, 2020.

[11] H. Theelen, A. van den Beemt, and P. den Brok, "Enhancing authentic learning experiences in teacher education through 360-degree videos and theoretical lectures: reducing preservice teachers' anxiety," *Eur. J. Teach. Educ.*, vol. 45, no. 2, pp. 230–249, Mar. 2022.

[12] C. Chen, "Immersive virtual reality to train preservice teachers in managing students' challenging behaviours: A pilot study," *Br. J. Educ. Technol.*, vol. 53, no. 4, pp. 998–1024, Jul. 2022.

[13] S. L. Rogers, R. Hollett, Y. R. Li, and C. P. Speelman, "An Evaluation of Virtual Reality Role-Play Experiences for Helping-Profession Courses," *Teach. Psychol.*, vol. 49, no. 1, pp. 78–84, Jan. 2022.

[14] C. J. Roberson and L. R. Baker, "Designing and Implementing the Use of VR in Graduate Social Work Education for Clinical Practice," *J. Technol. Hum. Serv.*, vol. 39, no. 3, pp. 260–274, Jul. 2021.

[15] R. Shadiev, X. Wang, and Y. M. Huang, "Cross-cultural learning in virtual reality environment: facilitating cross-cultural understanding, trait emotional intelligence, and sense of presence," *Educ. Technol. Res. Dev.*, vol. 69, no. 5, pp. 2917–2936, 2021.

[16] H. Huang, C. Lin, and D. Cai, "Enhancing the learning effect of virtual reality 3D modeling: a new model of learner's design collaboration and a comparison of its field system usability," *Univers. Access Inf. Soc.*, vol. 20, no. 3, pp. 429–440, Aug. 2021.

[17] İ. Erkan, "Investigation of the contribution of virtual reality to architectural education," *Art, Des. Commun. High. Educ.*, vol. 19, no. 2,
pp. 221–240, Oct. 2020.

[18] B. Nisha, "The pedagogic value of learning design with virtual reality,"
Educ. Psychol., vol. 39, no. 10, pp. 1233–1254, Nov. 2019.

[19] D. S. Özgen, Y. Afacan, and E. Sürer, "Usability of virtual reality for basic design education: a comparative study with paper-based design," *Int. J. Technol. Des. Educ.*, vol. 31, no. 2, pp. 357–377, Apr. 2021.

[20] J. Radianti, T. A. Majchrzak, J. Fromm, and I. Wohlgenannt, "Computers & Education A systematic review of immersive virtual reality applications for higher education : Design elements , lessons learned , and research agenda," *Comput. Educ.*, vol. 147, no. November 2019, p. 103778, 2020.

[21] A. Vogt, F. Babel, P. Hock, M. Baumann, and T. Seufert, "Immersive virtual reality or auditory text first? Effects of adequate sequencing and prompting on learning outcome," *Br. J. Educ. Technol.*, vol. 52, no. 5,
pp. 2058–2076, 2021.

[22] M. Lui, R. McEwen, and M. Mullally, "Immersive virtual reality for supporting complex scientific knowledge: Augmenting our understanding with physiological monitoring," *Br. J. Educ. Technol.*, vol. 51, no. 6, pp. 2181–2199, Nov. 2020.

[23] S. Klingenberg, M. L. M. Jørgensen, G. Dandanell, K. Skriver, A. Mottelson, and G. Makransky, "Investigating the effect of teaching as a generative learning strategy when learning through desktop and immersive VR: A media and methods experiment," *Br. J. Educ. Technol.*, vol. 51, no. 6, pp. 2115–2138, Nov. 2020.

[24] M. D. Miller, G. Castillo, N. Medoff, and A. Hardy, "Immersive VR for Organic Chemistry: Impacts on Performance and Grades for First- Generation and Continuing-Generation University Students," *Innov. High. Educ.*, vol. 46, no. 5, pp. 565–589, Oct. 2021.

[25] S. Valenti, B. Lund, and T. Wang, "Virtual Reality as a Tool for Student Orientation in Distance Education Programs," *Inf. Technol. Libr.*, vol. 39, no. 2, Jun. 2020.

[26] F. J. Agbo, I. T. Sanusi, S. S. Oyelere, and J. Suhonen, "Application of virtual reality in computer science education: A systemic review based on bibliometric and content analysis methods," *Educ. Sci.*, vol. 11, no. 3, 2021.

[27] Z. Yu, "A meta-analysis of the effect of virtual reality technology use in education," *Interact. Learn. Environ.*, vol. 0, no. 0, pp. 1–21, 2021.

[28] M. Slater and M. V. Sanchez-Vives, "Enhancing Our Lives with Immersive Virtual Reality," *Front. Robot. AI*, vol. 3, no. December, pp. 1–47, 2016.

WIKIPEDIA AND MEDIAWIKI: TWO KEY ELEMENTS OF A WIKIPEDAGOGY PRACTICE

Teresa Cardoso
Departamento de Educação e Ensino a Distância
Universidade Aberta
Portugal
https://orcid.org/0000-0002-7918-2358

Filomena Pestana
Rede Académica Internacional WEIWER®, LE@D
Universidade Aberta
Portugal
https://orcid.org/0000-0003-3146-8792

***Abstract*— In this text we aim to present the planning of the curricular integration of Wikipedia in Higher Education, more specifically in the course "Research in Education", of the 1st year, 1st semester, of the Master programme in Information Management and School Libraries of the Open University Portugal. The pedagogical exploration of this encyclopedia in this master's degree began in the academic year of 2020/2021. However, the innovation now lies in the fact that we are proposing to replace one of the platforms formerly used (Google Docs) by MediaWiki, and expand the activities in this software. So, in addition to editing the Wikipedia articles in the encyclopedia's main domain, students will simultaneously work in the Wikipedia test pages and in the Open Textbook, also created in MediaWiki, about the topics related to the 3rd theme of the course, 'Research in Education: data collection and analysis'. At a pedagogical level, work is designed to be collaborative, bearing in mind active methodologies, like Flipped Learning, in the framework of Open Education, ultimately targeting at the development of the Wikiliteracies, as embodied in a Wikipedagogy practice.**

Keywords—open education, open educational resources, open educational practices, university education, Wikipedia curriculum integration.

I. INTRODUCTION

Information and Communication Technologies (ICT) and Networked Educational Technologies (NET) today are unavoidable elements in education, namely when we envisage both the curricular and pedagogical integration of the contemporary online encyclopedia – Wikipedia [1]. Undoubtedly, Wikipedia is a resource that is accessed all over the world, being used as a source for carrying out school and academic work [2]. It is important to highlight that, in addition to the acquisition of a broad set of skills, it is transversally embodied in the areas of digital literacy and information literacy, either when promoting a critical reading of Wikipedia articles, or by editing them [3][4][5]. And, although not yet explicitly, nor generalized, we currently identify teachers and institutions that promote it as a tool to stimulate the teaching-learning process in different scientific fields and levels of education [6][7]. However, the curricular integration of Wikipedia, in an educational context, is still essentially carried out in Higher Education, though it also occurs at other levels of education, depending on the function assigned to it [8][9]. In the case reported in this text, the integration refered to is focused on the *Mestrado em Gestão da Informação e Bibliotecas* (MGIBE) (Master in Information Management and School Libraries) of the *Universidade Aberta* (UAb) (Open University Portugal), more specifically on the course or Curricular Unit (CU) of *Investigação em Educação* (Research in Education).

Our purpose is focused in presenting the planning that gave rise to the curricular and pedagogical integration of Wikipedia in the specific course already mentioned, an educational context that is sustained in Open Education, which we address in the following section, among other theoretical milestones. Then, we identify and contextualize the planning of the course itself, before concluding with brief final considerations.

II. THEORETICAL CONTEXTUALIZATION

A. *Open Education*

Before starting the theoretical contextualization of Wikipedia, it is important to relate this current phenomenon to Open Education (OE) and, consequently, to the role that Open Educational Resources (OER) and Open Educational Practices (OEP) assume in it. Therefore, we understand OE in the line of [2], that is, we revisit both the founding concepts (motivations) and the practices and challenges (implementations) of OE. Thus, we highlight, among the founding concepts, the "Open Access Education" movement, the "Web 2.0 Culture" and the "Open Source Software" movement; among the practices and challenges, we highlight phenomena such as "Open Access", "Open Scholarship" and "Open Educational Resources". As can be seen from the above, the concept of OE is assumed as a broad and aggregating concept, given its wide scope. Hence, with a view to systematizing the concept of OE, as in [2] [10] [11], we remember that this phenomenon integrates Resources, Tools and Practices, whether individual or institutional, with a view to promoting access, efficiency, success, and equity in education around the world. Therefore, we underline the role that OER assume, specifically one of the identified aspects – Resources –, which, as in [12], refers to teaching, learning and research materials regardless of the medium, be it digital or not. Another important feature is the fact that the resource is available in public domain or has an open license that allows access, use, adaptation and sharing by third parties without restrictions or with limited restrictions. The OEP, identified by Practices, refer, among other aspects, to the integration of OER in teaching practices [13], being more concretely understood as pedagogical practices that are associated with collaborative work and the use of "participatory technologies and social networks for interaction, peer-learning, knowledge creation, and empowerment of learners" [14, p. 4], intimately associated with the creation, use and reuse of OER. It is important, in this context, to recognize that Wikipedia can be considered an OER and, as such, it is capable of being translated into an OEP, as in the case presented in [15]. Is is also important to mention that the curricular and pedagogical integration of Wikipedia stems from research that has been carried out in the WEIWER® International Academic

Network, a network devoted to Wikis, Education & Research, with the following goals: to disseminate OEP where Wikipedia plays a relevant role; to disseminate research results in the field of training and open education with Wikipedia, with a view to building new lines of research and development; to stimulate critical reflection on the curricular integration of Wikipedia, namely in the context of continuous training of teachers and trainers; to promote other Wikimedia Foundation ecosystem projects; to establish intervention networks in the field of OEP, specifically in the context of Wikipedia [16].

With regard to the OEP, it is important to mention a set of dimensions and axes within a typology of action. Therefore, as in [14], four dimensions can be identified, the first of which refers to "Balancing privacy and openness", reflecting the need for educators to make a careful assessment of issues associated with privacy as opposed to openness, a situation that we also consider as relevant, namely because it is one of the criteria that we adopted when designing the pedagogical strategy of the WEIWER® Programme, in particular the curricular integration of Wikipedia. This dimension is essential, especially when we are working with young people, specifically from Basic and Secondary Education; in Higher Education and in Adult Education, the situation of "balancing" can assume other aspects. A second dimension, "Developing digital literacies", is associated with the fact that OEP promote digital literacies, mainly with regard to "ICT proficiency; information, media and data literacy; digital creation, communication and collaboration; digital learning and personal/professional development; and digital identity and wellbeing" [14, p. 10], which we also corroborate. In the different proposals for curricular integration of Wikipedia, as we conceive, implement and evaluate them, digital literacies and competences are targeted, moreover in line with Portuguese and European references that frame and support the aforementioned WEIWER® Programme, such as the Action Plan for Digital Education 2021-2027 [17], and the European Framework for the Digital Competence of Educators: DigCompEdu [18]. A third dimension to be considered, also as in [14], still within the scope of the OEP, is "Value social learning", associated with socio-constructivism and, therefore, the role that students can play in their learning process, more specifically in student-centered learning environments, as recommended in [19] [20]. The appreciation of this third dimension results, as a consequence, for example, in the devaluation of the "didactic lecturing style", that is, from the perspective of the teacher, it is articulated with a fourth dimension, "Challenging traditional teaching role expectations", which highlights the innovative character of the OEP, in general, and of the WEIWER® pedagogical-curricular strategies, in particular.

Regarding the axes of a typology of action, for the OEP, as in [13], three axes are identified:

1) from centered on content to centered on process;

2) from teacher-centered to student/student-centered;

3) from primarily focused on pedagogy to focused on social justice.

This last axis, when essentially focused on social justice, can be directed towards three aspects, namely: *a) economic and/or; b) cultural and/or; c) political (political injustice).*

Returning to the three axes identified in [13], and listed above, we proceed to their explanation. Thus, the axis "from centered on content to centered on process" refers to the role played by, among others, by Open Textbooks (OT). Considering, then, the examples of OT, if they are centered on content, they are assumed as OER that support the pedagogical strategy, being created for this purpose (content); if they are centered on the process, their interest lies precisely in the creation process, especially if it is assumed by the students themselves. As for the second axis, "from centered on the teacher to centered on the student/student", and considering the same example, of the OT, it can be seen that they are centered on the teacher if the phenomenon of openness is centered on the teacher; or, on the contrary, they are student/student centered if they are created by the students. In the third axis, "from mainly focused on pedagogy to focused on social justice", the OT are associated with the prevalence of either pedagogical issues or social justice issues; that is, the teacher can use a certain OT mainly for pedagogical reasons, given that it is the most appropriate to the situation, or for reasons of social justice, in particular for economic and/or cultural and/or political reasons (cf. respectively the three aspects – economic, cultural and political – also listed above). Before proceeding, let us dwell on the words of the authors, which we quote [13, p. 11]: "Crowdsourced, collaborative knowledge creation such as in Wikipedia is both content and process-focused, since this creation of knowledge involves conducting research and working with others who are editing the content, including using discussion/talk pages (e.g. Wikipedia) or commenting features (e.g. Google docs) to negotiate knowledge with others. If learners are engaged in creating knowledge in this way, this is student-centric".

Lastly, and also with regard to the OT, it should be noted that these, due to the open license they hold, not only form part of the movement associated with openness, but also register as OER that can be embodied in OEP [21] [22] [23] [24]. And they will be able to assume several characteristics, of which we highlight two, focused on openness: the OT are distributed free of charge, through their open license, to students, teachers and the general public [21]; OT, through their open license, allow everyone "to reuse, remix, revise, redistribute and retain them". That is, they are not static resources, but dynamic resources insofar as they allow their updating and configuration, according to the strategies identified by teachers and/or students involved in the OEP [24, p. 4]. [24] argues that for students, a OT is a resource that "helps them to understand knowledge as an ongoing process in which they play an active role"; for teachers, however, it allows them to be involved "as part of a broader move towards 'open pedagogy', which emphasizes opencontent and open practices". And, those authors also clarify that "[t]his approach not only helps to give learners ownership of the curriculum, but it also shifts their attitude. Knowledge is not fixed and static; it is an ongoing process involving learners" [24, p. 16].

B. Wikipedia in Higher Education

Wikipedia as the current encyclopedia emerged in 2001 by the hand of its founders Jimmy Wales and Larry Sanger; initially, it presented as a project without much credit, due to the idea that anyone could edit it, that is, without the traditional top/down process of creating entries as implemented by traditional encyclopedias. However, today, Wikipedia is an unavoidable resource, particularly when doing an online search; it is used by pupils/students of all levels of education, including higher education. The Wikimedia Foundation is the foundation that sustains Wikipedia, and a wide range of projects, called sister projects, such as Wikimedia Commons, Wikiversity, Wikibooks, Wikidata; it has formed partnerships with educational institutions around the world, including in Portugal. Wikipedia is governed by a broad set of fundamentals, pillars and rules, and the collaboration of this community of practice [2] is carried out with both human and non-human agents, thus constituting a socio-technical system [25]. With regard to the software that supports it, it is a Wiki, more specifically MediaWiki, which, like Wikipedia articles, is also an OER, as it has an open license. It is important to point out that, as a Wiki, it incorporates the possibility of hosting valid pedagogical practices in the teaching/learning process, namely due to its capacity for collaboration and, despite being a product of Web 2.0, it still presents itself as an innovative resource at a pedagogical level [26] [27] [28].

Within the scope of partnerships established with higher education institutions, we highlight the work carried out both in the USA and in Canada, through Wikipedia Education Program, which began in 2010 [2] [29]. [29, p. 254] identifies a set of data relating to the Wikipedia Education Program that translates the magnitude of the program, namely that has "supported over 43,000 students in higher education institutions across the US and Canada since 2010, adding over 44 million words to Wikipedia". In the United Kingdom, the numbers are lower; in fact, with regard to the institutions involved, and taking into account the 2018/19 academic year, around 15 universities promoted initiatives in that context, of which Edinburgh University, Queens University Belfast, Imperial College London, Stirling University stand out. In the context of Portuguese-speaking Wikipedia, we highlight the Wikipedia at the University Program; [25] mapped and meta-analyzed 92 initiatives carried out by 22 higher education institutions between 2011 and 2018. On the other hand, the University of Derby (UoD), as in [29], from the phenomenon designated by "Wikiliteracy", identifies a framework that fits the issues associated with Information Literacy and Wikipedia (Table I), a literacy especially relevant to the area of MGIBE, UAb.

TABLE II. UNIVERSITY OF DERBY (UOD) INFORMATION LITERACY FRAMEWORK AND WIKIPEDIA [29, p. 256]

Abilities	**UoD Information Literacy Framework learning outcomes**	**Wikipedia activities**
1. Identify	Identify a personal need for information.	Use a Wikipedia article to familiarise self with rough concept and context.
2. Scope	Assess current knowledge and identify potential sources of information.	Use Wikipedia article references to identify sources used.
3. Plan	Construct strategies for locating information and data.	Research topic using open access sources fromWikipedia – then compare same research using library subscription sources.
4. Gather	Locate and access the required information and data.	Use library subscription sources to provide references for articles with unverified claims.
5. Evaluate	Review the research process and compare/evaluate information and data.	Compare a Wikipedia article with a traditional encyclopaedia article, textbook or journal article.
6. Manage	Organise information professionally and ethically Enhance articles by locating references for unverified claims.	Find suitable images for re-use using Wikimedia Commons or Creative Commons.
7. Present	Present, disseminate, apply and synthesise the knowledge gained.	Discuss importance of neutrality in writing Wikipedia articles. Expand existing Wikipedia articles using quality academic sources.Create new articles.

[25], in the Table I, makes it clear how easy it is to work on issues associated with Information Literacy with Wikipedia. At the same time, we would add that this easiness also exists with regard to the possible combinations at the pedagogical level in the advanced framework in [22], previously identified and explained, and which were considered in the curricular amd integration of Wikipedia that we present in this text, particularly as follows.

C. Curricular Integration of Wikipedia in MGIBE

As previously mentioned, the CU "Research in Education" is a CU from MGIBE, a master's degree taught at Universidade Aberta, Portugal; it is a CU of the 1st Semester of the 1st year of the programme. Like all of UAb's pedagogical offer, MGIBE is also delivered completely in distance learning. The CU is organized in three themes:

1) Research in Education: stages and characteristics;

2) Research in Education: paradigms and methodologies;

3) Research in Education: data collection and analysis.

With regard to the third theme, which we focus in this text, it includes two sub-themes:

a) Procedures and techniques for data collection in research in education;

b) Procedures and techniques for data analysis in research in education.

This was, in broad terms, the context that gave rise to the instructional design of the curricular integration of Wikipedia, with students being challenged, at first, to create a team with a colleague, after which they had to select a data collection technique research in education, or a procedure and technique for analyzing data in research in education, to support their work. Once these steps were completed, they should reflect critically on the corresponding Wikipedia article, if it exists, and present a proposal for deepening it; if it did not exist, they should present a proposal for its creation. The support could be the main domain from the Portuguese-speaking Wikipedia, the Wikipedia test pages or in the OT created in MediaWiki, maintaining, however, the formatting that characterizes the articles in this online digital encyclopedia. After completing the work in pairs, there was a peer review by the other teams, with debates taking place in the Theme 3 forum, at the course institutional LMS (moodle). Despite not being the purpose of this text, it is important to note that the activity was well received; as a product, students created an article from scratch on Wikipedia and articles on test pages or in MediaWiki. It is important to point out that we initially worked with Google Docs, so an innovation now is to work for the first time with the MediaWiki OT created for this purpose.

The activity took place in the 1st Semester and integrates an extra synchronous session, promoted by the WEIWER® International Academic Network. Usually in this WEIWER® Open Sessions, under the motto "A look at Wikpedia", one of the administrators of the Portuguese-speaking Wikipedia is invited.

With regard to the pedagogical dimension, and returning to the systematization carried out in [25], which underlies the integration strategy that provided for the creation and/or editing of Wikipedia articles, we can classify our pedagogical and curricular proposal as representative of an axis focused both on the process and on the content, in addition to an axis focused on the student, and, finally, an axis focused on the pedagogy. Moreover, and complementing the systematization carried out as in [25], previously presented in Table 1, we can consider that all the "Abilities" identified in the context of Information Literacy were foreseen and achieved – "Identify", "Scope", "Plan", "Gather" , "Evaluate", "Manage", "Present". Ultimately, with the activity it was intended that, through an active methodology, namely as in [20] via a Flipped Learning approach, students collaborate in the co-compilation of an OT that translates the dimensions associated with both sub-themes explained previously, which we now recall: a) Procedures and techniques for data collection in research in education; b) Procedures and techniques for data analysis in research in education.

Before concluding, we visually represent, in Figure 1, the articulation between the different virtual learning environments of the activity proposed and described in the context of the MGIBE's course, "Research in Education", at UAb; in Table 2, we present its curricular characterization form.

Fig. 1. Articulation between the different virtual learning environments of the activity

TABLE III. CHARACTERIZATION OF THE ACTIVITY "RESEARCH IN EDUCATION: DATA COLLECTION AND ANALYSIS" [29]

Guidelines Theme 3	**Research in Education: Data Collection and Analysis**
What is expected	[1st week] – Individual and group work to create/update a Wikipedia article on a data collection technique and respective(s) analysis technique(s). In the end, the various Wikipedia articles should allow to answer to the following questions: *1) What data collection procedures and techniques should research in education favor?* *2) What procedures and techniques are suitable for data collection in research in education?*
	[2nd and 3rd week] – Participation in the Theme 3 Forum, sharing the created/updated Wikipedia article and commenting on those of the colleagues.
Resources	In addition to those previously indicated, as well as in addition to those students are expected to search and share, the following should be considered: Metodologia da pesquisa científica. (2019, setembro 8). Wikipédia, a enciclopédia livre. https://shre.ink/l0DI Pestana, F. & Cardoso, T. (2020). Wikipédia como um REA no Ensino Superior: um Caminho da Utopia à Realidade. *Internet Latent Corpus Journal*, 9(1), pp. 80-93. Programa Wikipédia no Ensino – Brasil e lusofonia. (2021, março, 2). Wikipédia a enciclopédia livre. https://shre.ink/l0Dl Wikipédia: Livro de estilo. (2022, dezembro, 16). Wikipédia a enciclopédia livre. https://shre.ink/l0DW
Assessement	Wikipedia article, prepared according to the following criteria for appreciation and classification: *1) mastery of concepts and perspectives, distinguishing what is essential from what is not;* *2) reasoned argumentation, with scientific rigor, clarity and linguistic correctness;* *3) Compliance with stylebook and deadline*. Participation in the Theme 3 Forum, according to the following evaluation and classification criteria: *1) relevant and timely comment, with constructive suggestions, to a minimum of 2 Wikipedia articles submitted by colleagues;* *2) meeting the deadline and the ability to contribute to an effective dialogue.*

III. CONCLUSION

For this text, which refers to a broader research, we don't aim to present results; these will be presented afterwards. Instead, we set the aim of presenting the planning of the curricular and pedagogical integration of Wikipedia, in a master's degree course, corresponding to an open educational practice in a university context. In fact, the issues associated with the phenomenon of openness in education allow that, together, both ICT and internet tools play a relevant role, namely in the scope of the integration of Wikipedia in higher education. Moreover, as in [31, p. 1026], Wikipedia "is an open educational resource that connects readers, writers, and editors across communities all over the world". [30] argues that, at the level of higher education institutions, there should be better knowledge of the current encyclopedia, namely the open and free character of open knowledge in which its product results from collaborative work governed by a broad set of policies, norms, rules, processes and evaluation criteria for Wikipedia articles, thus improving perceptions and attitudes towards its use. It is in this scenario that we frame the work we have been developing in the WEIWER® International Academic Network. In other words, we have been implementing the integration of Wikipedia at different levels of education, that is, we have been developing OEP that represent, for example, the acquisition of skills that go beyond the skills that are possible to mobilize when working only with traditional resources. This is illustrated in the curricular and pedagogical integration of Wikipedia we proposed in the CU of "Research in Education" of the MGIBE at UAb, Portugal, which took place specifically throughout the Theme 3

"Research in Education: data collection and analysis". To conclude, such a curricular and pedagogical design is yet another evidence that Wikipedia Participation is a Novel Literacy [4], catering for multiple 21st Century abilities [29], in which Wikipedia and MediaWiki are two key elements, to be taken into account towards a Wikipedagogy practice.

References

[1] M. Proffitt, "Why Wikipedia and Libraries?" M. Proffitt (Edt.) Leveraging Wikipedia: connecting Comunities of Knowledge, pp. 1-6. ALA Editions, 2018.

[2] F. Pestana, "A Wikipédia como recurso educacional aberto: umcontributo parao Programa Wikipédia na Universidade". (PhD Thesis, Universidade Aberta, Lisboa, Portugal), 2018.

[3] T. Jacobson, "Analyzing Information Sources Through the Lens of the ACRL Framework: A Case Study of Wikipedia". Communications inInformation Literacy, 14(2), 362-377, 2020. https://doi.org/10.15760/

[4] A. Lockett, "The Politics of User Agency and Participation on Wikipedia". J. Reagle & J. Koerner (Org.) Wikipedia @20 Stories of an Incomplete Revolution. MIT Press, 2020.

[5] P. Thomas, M. Jones, and S. Mattingly, "Using Wikipedia to teachscholarlypeer review: A creative approach to open pedagogy". Journal of InformationLiteracy, 15(2), 178-190, 2021. http://dx.doi.org/10.11645/15.2.2913

[6] T. Cardoso, F. Pestana and M. Castrelas, "As Tecnologias Educacionais em Rede à Luz dos Quatro Pilares da Educação: uma Utopia Global?". P. Calvacanti (Org.) Educação: Teorias, Métodos e Perspectivas, vol. IV, pp. 24-36. Editora ARTEMIS, 2021.

[7] S. Humer and M. Schnetzer, "Wikipedagogy: Enhancing student motivationand collaboration in an economics class with Wikipedia", The Journal of Economic Education, 53:1, 43-51, 2022.

[8] T. Cardoso, F. Pestana, P. Queirós and L. Queirós, "Formação de Professoresno Contexto Pandémico: o papel das Tecnologias Educacionais em Rede". F. Boas & O. Silva (Org.) Ensino Remoto e Formação de Professores: construçãode novos saberes para os processos educativo, Capítulo II, pp. 39-56. Editora Pontes, 2022.

[9] F. Pestana and T. Cardoso, "Meta-análise da página lusófona do ProgramaWikipédia na Universidade: proposta de sistema metodológico a partir do MAECC®", Indagatio Didactica, 12(3), 245-264, 2020.

[10] G. Conole and M. Brown, "Reflecting on the impact of the Open Education Movement". Journal of learning for Development, 5(3), 187-203, 2019.

[11] C. Cronin and I. MacLaren, "Conceptualising OEP: A Reviewof Theoretical and Empirical Literature in Open Educational Practices". Open Praxis, 10(2), 127-143, 2018.

[12] UNESCO, "2012 Paris OER Declaration", 2012. https://unesdoc.unesco.org/ark:/48223/pf0000246687_por?posInSet=5&queryId=N-EXPLORE-fe423128-fa29-4785-b061-b193c410f29e

[13] M. Bali, C. Cronin and R. Jhangiani, "Framing Open Educational Practices from a Social Justice Perspective". Journal of Interactive Media inEducation, 2020(1), 10, 2020. http://doi.org/10.5334/jime.565

[14] C. Cronin, "Openness and Praxis: Exploring the Use of Open Educational Practices in Higher Education". The International Review of ResearchinOpen and Distributed Learning, 18(5), 1-21, 2017.

[15] T. Cardoso and F. Pestana, "Wikipédia, um recurso educacional aberto?" EmRede - Revista de Educação a Distância, 5(2), 300-318, 2018.

[16] T. Cardoso, F. Pestana and J. Pinto, "Wikis, Education & Research: the International Academic Network WEIWER®". L. Chova, A. Martínez, I. Torres (Eds.) EDULEARN20 Proceedings, pp. 8602-8608, 2020.

[17] European Union, "The Digital Education Action Plan (2021-2027): Resettingeducation and training for the digital age" [Deap Fact Sheet], 2020. https://ec.europa.eu/education/sites/default/ files/document-library- docs/deap-factsheet-sept2020_en.pdf

[18] M. Lucas and A. Moreira, "DigCompEdu: Quadro Europeu de Competência Digital para Educadores". UA Editora, 2018. http://hdl.handle.net/10773/24983

[19] T. Cardoso and F. Pestana, "Wikipedia belongs to education? A pedagogical model to sustain it!" [PPT]. CC Global Summit, 19-23 October 2020. https://repositorioaberto.uab.pt/ handle/10400.2/10969

[20] T. Cardoso and F. Pestana, "O Papel do Eixo Estudante/ConhecimentonoTriângulo Pedagógico em Contexto de Blended (e)Learning". P. Calvacanti (Org.) Educação: Teorias, Métodos e Perspectivas, volume II, Capítulo16, pp. 187-199. Editora ARTEMIS, 2021.

[21] A. Algers, "Open Textbooks: A Balance Between Empowerment and Disruption". Tech Know Learn, 25, 569-584, 2020. https://doi.org/10.1007/s10758-019-09426-5

[22] T. Cardoso and F. Pestana, "O programa WEIWER® como nova alfabetização: casos à Luz de uma tipologia de Práticas Educacionais Abertas". J. Rodrigues & M. Marques (Org.) Ciências socialmente aplicáveis: integrando saberes e abrindo caminhos, vol. VI, pp. 126-139. Editora Artemis, 2022.

[23] R. Farrow, R. Pitt and M. Weller, "Open Textbooks as an Innovation Route for Open Science Pedagogy". Education for Information, 36, 227-245, 2020.

[24] R. Ferguson, *et al.* "Innovating Pedagogy 2017: Open University Innovation Report 6". The Open University, UK, 2017.

[25] T. Cardoso and F. Pestana, "Wikipédia, um lócus de (des)encontros entreagentes humanos e não humanos?". A. Silva & A. Subrinho (Org.) AEducação enquanto fenômeno social: um estímulo à transformaçãohumana, volume 3, capítulo 7, pp. 70-83. ATENA Editora, 2022.

[26] A. Alharbi, "Wikis in Language Learning: Merits and Limitations". Journal of English Language Teaching and Applied Linguistics, 2(4), 79-88, 2020.

[27] J. Fisher and S. Allred, "Using Crowdsourced Wikis to Teach an Online Undergraduate Course". Online Learning Journal, 24(3), 163-183, 2020. https:///doi.org/10.24059/olj.v24i3.2152

[28] G. Sula and A. Sulstarova, "Using wikis as a teaching tool for novice teachers – Pedagogical implications". Journal of Learning for Development, 9(2), 163- 175, 2022.

[29] C. Ball, "WikiLiteracy: Enhancing students' digital literacy with Wikipedia". Journal of Information Literacy, 13(2), 253-271, 2019. http://dx.doi.org/10.11645/13.2.2669

[30] T. Cardoso, "Contrato de Aprendizagem da UC 12150 (MGIBE)", 2021. https://elearning.uab.pt/mod/resource/view.php?id=711061

[31] D. Zou, H. Xie, F. Wang and R. Kwan, "Flipped learning with Wikipedia in higher education", Studies in Higher Education, 45:5, 1026-1045, 2020.

WIKIPEDIA IN UNIVERSITY PROGRAM: META-ANALYSING THE ACTORS IN THE LUSOPHONE PAGE

Filomena Pestana
Rede Académica Internacional WEIWER®, LE@D, Laboratório de Educação a Distância e eLearning
Universidade Aberta
Portugal
https://orcid.org/0000-0003-3146-8792

Teresa Cardoso
Departamento de Educação e Ensino a Distância
Universidade Aberta
Portugal
https://orcid.org/0000-0002-7918-2358

***Abstract*—The curricular integration of Wikipedia has the potential to create Open Virtual Learning Environments that promote a broad set of skills. It should be noted that the Wikimedia Foundation, a foundation that supports a number of projects, including Wikipedia, is particularly interested in partnerships with educational institutions, particularly at the higher education level. It is in this context that the page of the Wikipedia Program at the University in the Portuguese-speaking context was meta-analyzed between the years 2011 and 2018. The research study was aimed at answering to the following question: - What do the courses registered on the Lusophone page of the Wikipedia Program at the University tell us? Given that it was achieved by meta-analysing a *corpus* of 92 interventions, we present, in this text, the part related to the meso category "actors", which, in turn, is included in the macro category "Methodologies". Hence, our specific question is: - Which actors are involved? Methodologically, this postdoctoral research is an exploratory, descriptive and meta-analytical study of a mixed nature, combining a quantitative and a qualitative approach. The MAECC®, Meta-model of Analysis and Exploration of Scientific Knowledge® was adopted as the methodological and analytical instrument, supported by document analysis, statistical analysis and content analysis. In the whole, the mapping obtained allows us to identify curricular areas, actors involved, pedagogical strategies, educational products and trends of each university involved in the program, expanding our understanding of this phenomenon. More specifically, the meso category "actors" allows us to identify those who were involved, namely: "teachers" (42), "students" (~3557) and "ambassadors" (62).**

Keywords*—Networked Educational Technology, Wikipedia in University Program, Meta-analysis, MAECC®, Knowledge Mapping.

I. INTRODUCTION

The network is assumed as an educational interface that integrates and provides the openness and sharing of knowledge [1], and in this context we consider Wikipedia, because it can be described as a source of information. Through collaborative and anonymous writing, and the self-regulation of the knowledge construction system, it can also be described, following [2], as a project with an undeniable contribution to the construction of collective intelligence. At the same time, we highlight that under the motto "Wikipedia belongs to education", the Wikimedia Foundation, an entity that financially supports several projects, including Wikipedia, has been targeting at partnerships with educational institutions, namely through the Wikipedia Education Program (WEP), which in turn integrates the Wikipedia in University Program (WUP) [3] [4] [5]. Bearing in mind this specific program, it was considered important to meta-analyse the page of the courses available in the context of the Portuguese-speaking WUP. For this purpose, we adopted, methodologically, the MAECC®.

The text is organized in five parts. The first part is the introduction, the second is dedicated to the theoretical contextualization, focusing issues related to open education, in general, and, spefically, to Open Educational Practices (OEP) and Open Educational Resources (OER). The third is dedicated to the methodological system of analysis [11], that is, the MAECC®. The fourth part is dedicated to the presentation and discussion of data inherent to the specific research question. The fifth, and last part, is the conclusion.

II. THEORETICAL CONTEXTUALIZATION

We have been defending Wikipedia as an OER [6] and as an Networked Educational Technology. Therefore, we are in the presence of a phenomenon that is part of Open Education, which, moreover, can be embodied as an OEP. Open Education, as in [5] [7] [8], integrates individual and/or institutional resources, tools and practices in order to promote access, efficiency, success and equity in education in the world. In this context, both the OER and the OEP are important.

Taking Wikipedia as an object of study and as a pedagogical strategy, we highlight that it is increasingly becoming present at different levels of education in the world, namely because the Wikimedia Foundation identifies as a priority the partnership with the various educational institutions, implementing the initiative designated as the Wikipedia in Education Program (WEP), which includes the Wikipedia in University Program (WUP). In Portugal, this partnership was made with the Portuguese Open University, *Universidade Aberta* (UAb), in 2016, through the, Laboratory of Distance Education and Elearning (LE@D) [9], and more recently through the WEIWER® (Wikis, Education & Research) International Academic Network, which has been promoting several initiatives, developed at different levels of education [10] [11]. The WEIWER® Network was officially set in 2018 with its Open Sessions, an event that fosters debate on issues associated to the Wikipedia phenomenon; it also promotes and studies a set of practices that embody the curricular and pedagogical integration of Wikipedia at different levels of education.

III. METHODOLOGICAL CONTEXTUALIZATION

The research carried out, of which this text is an excerpt, aims to answer to the following specific question: Which actors are involved in the Portuguese-speaking WUP? Our research design embodies an approach that combines quantitative and qualitative methods.

With regard to MAECC®, as in [12], the systematization of knowledge, carried out via a mixed or multimodal meta-analysis, allows to combine document analysis from a qualitative and quantitative perspective with content analysis, privileging the theories proposed by van der Maren (1996), categorized according to the following levels: description, understanding, explanation and formalization of knowledge; these levels promote an appropriation of critical and reflective knowledge on the issues being analysed. It is important to clarify our understanding of meta-analysis, sustained, for this purpose, by the perspective of Gene Glass, who introduced the term for the first time, in 1976. Thus, as in [13, p.3], "[m]eta-analysis refers to the analysis of analyzes. I use it to refer to the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating the findings".

From the meta-analysis, we considered for our study, as in [14], the following procedural steps: (a) the selection and inclusion of all existing courses on the platform of the WUP; (b) the definition of inclusion and exclusion criteria, for the constitution of the *corpus*; (c) the development of the coding categories, to cover most of the identified courses; (d) the analysis and graphic representation of the results and their presentation; (e) the combination of quantitative and qualitative reviews. Figure 1 systematizes the conceptual model built for our meta-analytical study, in its various phases, which we describe below.

As in [14], Phase 1 (Collection) was based on documental analysis and resulted in the identification of the documents to be included in the *corpus*. For this purpose, the inclusion and exclusion criteria of the documents to be (meta) analysed, and the respective research descriptors, were defined and applied. Phases 2 and 3 (Treatment and Organization) refer to stages of consecutive readings, through which the information in the texts of the *corpus* gradually emerged from each document, induced by the content analysis, in a constant resource to the data and in a permanent dialogue with it. The analytical units were recorded in the analysis instrument, according to the defined categorical matrix. It is important to remember that we had the support of MAECC® and, therefore, we incorporated its five macro dimensions (Characterization, References, Methodologies, Contributions, Implications). Finally, Phase 4 (Diffusion) closes the methodological sequence of this study.

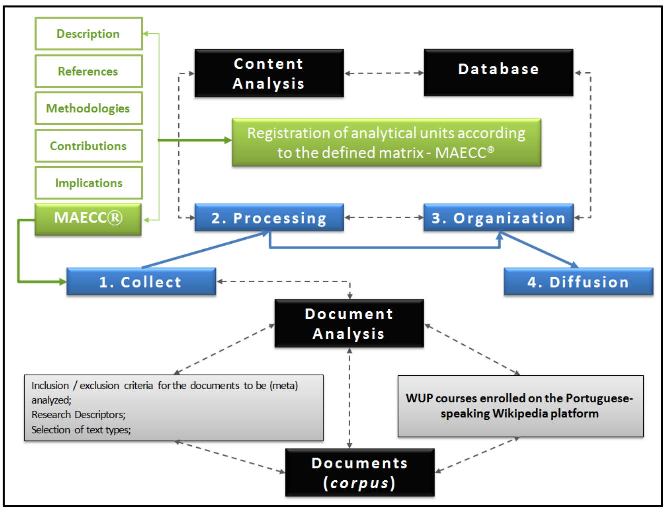


Fig. 1. Methodological analysis system: conceptual model (translated from [12])

In the next section, we present the context that supported the research and we present the corpus. Then, we address the principles and procedures for the application of the methodological system of analysis.

A. Context

WUP is part of WEP and the Portuguese speaking WUP website gathers all the courses developed under this program in the Portuguese language (https://bit.ly/31jyHVv). The welcome page, as its name implies, welcomes people potentially interested in the program and it is also directed to the actors directly involved in the program – i.e. teachers, students and Wikipedians, specially Wikipedia Ambassadors. In addition to the welcome page, the program includes the tabs "Courses", "Campus Ambassadors", "Online Ambassadors", "Resources" and "Help". The "Courses" tab aggregates the courses taught in Portuguese within this program (cf. Figure 2).

Fig. 2. Screenshot of the "Courses" tab of the WUP page in Portuguese (https://bit.ly/31jyHVv)

At the date of the definition of our *corpus*, the meta-analysis period identified was between 2011-2018. The "Courses" tab of the Lusophone WUP page totalled 92 courses during that time, that is, our *corpus* of analysis is limited to those eight years [12]. It is important to note that in 2019, 1 course was added and in 2020, another one. However, we also acknowledge that after that time, the courses in Portuguese began to be implemented through the Wikimedia Foundation's Outreach Dashboard (https://pt.wikipedia.org/wiki/Wikipédia:Outreach_Dashboard) and no longer are listed in the WUP page; the courses based in the US and Canada are aggregated in a dedicated portal (https://outreachdashboard.wmflabs.org).

Addressing again our attention to the context of our research, and regarding the meso category "Curricular Area", among the 92 educational interventions, 41 were in the field of "Exact Sciences" and 51 in the field of "Social and Human Sciences" [15]. Next, we present the *corpus* that was meta-analyzed; in other words, we list the 92 courses we mapped.

1. Desenvolvimento de Software Livre
2. Sistemas Multimidia
3. A história romana na Wikipédia
4. História da Cultura
5. Eletromagnetismo
6. Espalhamento Elástico de Luz e Raios-X por Biossistemas
7. Política Cultural
8. Antiguidade Clássica
9. Memória e Vivência
10. Curso de extensão

11. Direito Sanitário
12. Atividades Acadêmico-Científico-Culturais
13. Cidade e Imaginário
14. Química Geral e Experimental
15. Equações Diferenciais
16. Design e Editoração
17. Física III-C – Física para engenharia
18. Literatura - Teoria e Crítica
19. Sistemas de Produção I
20. Tópicos Especiais em Biologia Evolutiva
21. Língua Latina 2
22. Evolução
23. Introdução às Tecnologias da Comunicação
24. Antropologia e Sociologia - Grandes Pensadores Brasileiros
25. Eletromagnetismo II
26. Seminário de Pesquisa em Cultura Histórica e Documento
27. Física III – C – Física para engenharia
28. Instrumentação Física
29. Cálculo Numérico
30. Aplicações da Matemática - A
31. Introdução ao Cálculo Fracionário
32. Sociedade de Consumo e Litígios em Massa
33. Tradução Inglês - Português
34. Planejamento Wikipédia na Universidade com FGV SP
35. Introdução às Tecnologias da Comunicação
36. WikiProjeto Medicina
37. Física IV Civil (FIS01223)
38. Cálculo Numérico (MAT01169)
39. Tradução do Alemão
40. Introdução às Tecnologias da Comunicação
41. Física III-C – Física para engenharia
42. Instrumentação Física
43. Física IV Civil (FIS01223)
44. Cálculo Numérico (MAT01169)
45. O Mundo Helenístico
46. Introdução às Tecnologias da Comunicação
47. Ciência Política
48. Matemática Aplicada II (MAT01168) (2014-2)
49. Análise I (MAP0101)
50. Cálculo Numérico (MAT01169)
51. Termodinâmica e Mecânica Estatística (FIS01232)
52. Gestão de Pessoas
53. Liderança e Comportamento Organizacional
54. Ciência Política
55. Sociologia
56. Gestão de Pessoas II
57. Gestão de Pessoas I
58. Criação de verbetes sobre História da Antiguidade Ocidental
59. Laboratório didático de Física e Práticas Pedagógicas VII
60. Física III-C – Física para engenharia
61. Comportamento Organizacional
62. Evolução: o sentido da vida
63. Criação de verbetes sobre História da Antiguidade Ocidental
64. Laboratório didático de Física e Práticas Pedagógicas VII
65. Instrumentação Física
66. Física III - C – Física para engenharia
67. Contextos Educacionais
68. Evolução: o sentido da vida
69. Ecologia Geral
70. Ciência Política
71. Biologia da Conservação
72. Ecologia Geral
73. História da Antiguidade Ocidental
74. Laboratório didático de Física e Práticas Pedagógicas VII
75. Introdução ao Cálculo Fracionário
76. Ciência Política
77. Comportamento Humano nas Organizações
78. Gerenciamento Editorial em Mídias Digitais: Jornalismo de Dados
79. Caminhão com Ciência
80. Tópicos Especiais em Ciência da Informação
81. História da Antiguidade Ocidental
82. Laboratório didático de Física e Práticas Pedagógicas VII
83. Gerenciamento Editorial em Mídias Digitais: Jornalismo de Dados
84. Gerenciamento Editorial em Mídias Digitais: Jornalismo de Dados
85. Extensão: Reformulação e construção de verbetes da Wikipédia na área de Teoria da História

86. Extensão: Reformulação e construção de verbetes da Wikipédia na área de Teoria da História

87. História Moderna II

88. Seminário de Pesquisa em História Antiga

89. Introdução à Biofotônica

90. Gerenciamento Editorial em Mídias Digitais: Jornalismo de Dados

91. Audiologia Educacional e Reabilitação Auditiva

92. Editatona de Prevenção em Saúde

B. *Analysis Instrument*

Before presenting the meta-analysis instrument (in Table II), we identify and characterize below the (macro, meso, and micro) meta-analysis categories of the study (in Table I).

TABLE I. META ANALYSIS CATEGORIES DEFINED FOR THE STUDY [12]

MAECC® Macro Categories	Description/Categories and Subcategories (MAECC® meso and micro levels)
Description	In this macro dimension of MAECC® it is intended to identify the: Name of the Course; Higher Education Institution; Year and Semester; Country where it was developed (meso level).
References	In this macro dimension of MAECC® it is intended to identify the: Curricular Areas implemented (meso level), namely Exact Sciences / Social and Human Sciences (micro level).
Methodologies	In this macro dimension of MAECC® it is intended to identify the: Actors (course participants) (meso level), namely Teachers, Students and Wikipedia Ambassadors (micro level); Format/Typology of courses available (meso level), namely Typology "A" (Edit-a-thon), Typology "B" (Dashboard), Typology "C" (Project Page), Typology "D" (Project with 4 pages – Main, Discussion, Resources and Help) (micro level).
Contributions	In this macro dimension of MAECC® it is intended to identify the: Level of Access to Information (meso level), namely Access Link Active/Inative (micro level).
Implications	In this macro dimension of MAECC® it is intended to identify the: Articulation with other initiatives (meso level).

Regarding the meta-analysis instrument grid itself, the example presented in the Table II illustrates the only Portuguese university represented in the Portuguese-Speaking WUP, and its course – "Educational Contexts"; the remaining (91) courses correspond were taught in Brazilian Higher Education institutions [9].

As we can see, the meso category "actors" is part of the macro category "Methodologies" aiming at identifying, quantifying and relating data, that is, aiming at meta-analysing data with regard to the micro categories "teachers", "students" and "ambassadors" involved in the 92 courses that our research *corpus* comprises.

TABLE II. COURSE META-ANALYSIS GRID "EDUCATIONAL CONTEXTS" [9, p. 365]

1. Description

- **1.1. Course Designation**: Wikipédia na Universidade/Cursos/Contextos Educacionais
- **1.2. Higher Education Institution**: Universidade Aberta
- **1.3. Year / Semester**: 2016 / 1st Semester
- **1.4. Country**: Portugal

2. References

- **2.2. Curricular Area**
  - **2.2.1. Exact Sciences:** —
  - **2.2.2. Social and Human Sciences:** ✓

3. Methodologies

- **3.1. Actors (course participants)**
  - **3.1.1. Teachers**: Teresa Cardoso (Teacher) and Filomena Pestana (Researcher)
  - **3.1.2. Students**: 4
  - **1.1.3. Ambassadors**: Alchimista
- **3.2. Course availability format / typology**
  - **3.2.1. Tipologia "A"** (Edit-a-thon)**:** —
  - **3.2.2. Tipologia "B"** (Dashboard)**:** —
  - **3.2.3. Tipologia "C"** (Project Page)**:** —
  - **3.2.4. Tipologia "D"** (Project with 4 pages – Main, Discussion, Resources and Help)**:** ✓

4. Contributions

- **4.1. Level of access to information**:
  - **4.1.1. Access Link Active:** ✓
  - **4.1.2. Access link not active:** —

5. Implications

- **5.1. Articulation with other initiatives**: Not detected.

IV. PRESENTATION AND DISCUSSION OF DATA

The 92 courses of the *corpus* of our meta-analysis include the participation of 21 Brazilian universities, where 91 courses were implemented, and 1 Portuguese university, where 1 course was carried out (cf. meso dimension – "Country" and macro dimension – "Characterization").

Recalling our specific research question, considered for this text – What actors are involved? –, it should be noted that in the meso dimension "actors" we identified three micro dimensions: "Teachers", "Students" and "Ambassadors", corresponding, respectively, to 42 teachers, approximately 3557 students and 62 Wikipedia ambassadors.

Regarding the 42 "Teachers", the majority (28) only implemented 1 course; on the contrary, Rafael Pezi has implemented the largest number of courses (12), followed by Juliana Bastos Marques and Flávia Varela (both implemented each 7 courses). Moreover, we identified the following "Teachers" who also implemented more than one course: Valério Andrade Melo 6 courses; João Alexandre Peschanski, 5. Besides, Esequia Sauter, Fábio Azevedo, Deborah Magnani, Lina Nagaka, Viktor Chagas, and Rafael Vasques Brandão implemented 4 courses each; Ruben Camargo has implemented, in his turn, 3 courses. Finally, Irandy Marcos da Cruz and Lucas Nicolau, each, implemented 2 courses.

Regarding the "Ambassadors" involved, we observe that this involvement can result in assisting one or several courses. Nevertheless, the majority of the "Ambassadors" were involved in only 1 course (39), whereas 15 were involved in 2 courses and 3 in 3 courses. In addition, we can see that the "Ambassador" Fábio Azevedo was involved in 12 courses, the "Ambassador" Vitor Mazuco in 8 courses, and the "Ambassadors" Célio Costa and Otavio, each, in 4 courses.

Still with regard to "Teachers" and "Ambassadors", it is important to highlight courses in which the actors embodied these two roles. For instance, both Fábio Azevedo and Rafael Pezzi represent such case, as the former was involved in 16 courses, 12 as an "Ambassador" and 4 as a "Teacher", and the latter was involved in 15 courses, 12 as a "Teacher" and 3 as an "Ambassador". The cases of Esequia Sauter and RadiX are also similar, since the first was involved in 4 courses with the role of the "Teacher", and as an "Ambassador" in 2 others; the second was involved in 2 courses as a an "Ambassador" and in 1 course as a "Teacher".

Finally, with regard to the data related to the micro category "Students", in this micro category, two situations are identified: courses where there is the indication of the specific number of students (e.g., 1839), and other courses where an approximate number of students is presented (e.g., ~1718). We have also identified a third situation, which was not considered for analysis, that of the courses (of 3 universities) of which the number of students involved is not indicated.

V. Conclusion

Under the motto "Wikipedia belongs to education", the Wikimedia Foundation created the PWE in 2010 and, within it, the WUP, with the aim of providing greater quality to the content available on Wikipedia, also involving the academic community in its construction and development. Wikipedia started in 2011 in Portuguese, and so it was considered important to map and meta-analyse the courses implemented in partnership with Higher Education institutions since then to answer to the following main question: - What do the courses of the Wikipedia in University Program registered in the Lusophone Wikipedia platform tell us? Specifically, this problem fits an exploratory study, of a descriptive and meta-analytical nature, of a mixed nature, integrating a quantitative and qualitative approach. Hence, the Meta-model of Analysis and Exploration of Scientific Knowledge® (MAECC®) was adopted as an analytical and methodological instrument, supported by document analysis, statistical analysis, and content analysis.

This text covers a part of a broader postdoctoral study, and the main purpose we targeted here was to identify, in the *corpus* we defined, which actors are involved in the courses referred to before, including in the previous paragraph.

So, in the period from 2011 to 2018, namely in the context of the 92 Portuguese-speaking WUP courses we meta-analyzed, these were delivered in 22 Higher Education institutions (21 Brazilian and 1 Portuguese). In the same context, 42 professors (teachers) and 62 Wikipedia ambassadors were identified. With regard to teachers and ambassadors, we can observe that while some were only involved in a single course, others implemented/assisted more than one course. The data collected evidences 4 professors who also assumed the role of Wikipedia ambassadors and vice-versa. The exchange of roles was carried out in different courses, that is, it was not carried out simultaneously, within the same course. As for the students involved, we recognized 3 situations: the number of students is specified; the number of students is estimated in approximate values; the number of students is not indicated. Hence, in the whole, we identified ~3557 students involved in the 92 courses of our research *corpus*.

To conclude, we can say that we the Portuguese-speaking WUP is a program that integrates projects of a wide scope, especially if taking into account the actors involved in the courses, namely teachers, students and Wikipedia ambassadors. Moreover, these courses, provided by Higher Education institutions in partnership with Wikimedia Foundation, are significant, mainly and above all, but not exclusively, to the educational actors who are committed to its implementation.

References

[1] F. Pestana, S. Brás and T. Cardoso, "A Rede como Interface Educativa: uma reflexão em torno de conceitos fundamentais", Revista Interfaces Científicas – Educação, vol. 6, nº 3, 2018, pp. 41-52.

[2] P. Lévy, P., "A Inteligência Colectiva. Para uma antropologia do ciberespaço". Lisboa: Instituto Piaget, 1997.

[3] F. Pestana, F., "A Wikipédia como recurso educacional aberto: conceções e práticas de estudantes e professores no ensino superior online", Master thesis. Universidade Aberta, 2014.

[4] F. Pestana, F., "A Wikipédia como Recurso Educacional Aberto: Práticas Formativas e Pedagógicas no Ensino Básico Português". Master thesis. Universidade Aberta, 2015.

[5] F. Pestana, F., "A Wikipédia como recurso educacional aberto: um contributo para o Programa Wikipédia na Universidade". PhD thesis. Universidade Aberta, 2018.

[6] T. Cardoso and F. Pestana, "Wikipédia, um recurso educacional aberto?", EmRede - Revista de Educação a Distância, vol. 5, n. 2, 2018, pp. 300-318.

[7] G. Conole and M. Brown, "Reflecting on the impact of the Open Education Movement", Journal of learning for Development, 5(3), 2019, pp. 187-203.

[8] C. Cronin and I. MacLaren, "Conceptualising OEP: A Review of Theoretical and Empirical Literature in Open Educational Practices", Open Praxis, vol. 10, nº. 2, 2018, pp. 127-143.

[9] F. Pestana and T. Cardoso, "Wikipedia in University Program: What Does the Metaanalysis of the Courses' Page Tells Us?" European Distance and E-Learning Network (EDEN) Proceedings 2020 Research Workshop, Lisbon, 2020a, pp. 359-367.

[10] T. Cardoso and F. Pestana, "O programa WEIWER® como nova alfabetização: casos à Luz de uma tipologia de Práticas Educacionais Abertas", J. Rodrigues and M. Marques (Org.) Ciências socialmente aplicáveis: integrando saberes e abrindo caminhos, vol. VI, (2022), pp. 126-139. Curitiba: Editora Artemis.

[11] T. Cardoso, F. Pestana, and J. Pinto, J. "Rede académica WEIWER: a Wikipédia como objeto de estudo?", PRISMA.COM, 40, 2019, pp. 107-117. https://doi.org/10.21747/16463153/40a1

[12] F. Pestana and T. Cardoso, "Meta-análise da página lusófona do Programa Wikipédia na Universidade: proposta de sistema metodológico a partir do MAECC®", Indagatio Didactica, vol. 12, nº 3, 2020b, pp. 245-264.

[13] G. Glass, "Primary, secondary, and meta-analysis of research", American Educational Research Association, vol. 5, nº. 10, 1976, pp. 3-8.

[14] T. Cardoso, "Interacção verbal em aula de línguas: meta-análise da investigação portuguesa entre 1982 e 2002". Universidade de Aveiro. PhD thesis, 2007.

[15] F. Pestana and T. Cardoso, "Meta-Análise da Página Lusófona do Programa Wikipédia na Universidade: O que nos diz a Macro Categoria Referenciais?", T. Cardoso (Org.). Educação e Ensino na Era da Informação, vol. II, 2021, pp. 16-31. Curitiba: Editora ARTEMIS.

INTELIGÊNCIA ARTIFICIAL E INVESTIGAÇÃO ACADÉMICA: UM ESTUDO EXPLORATÓRIO COM ESTUDANTES DE MESTRADO

Teresa Gouveia
Departamento de Comunicação e Arte
Escola Superior de Educação de Viseu
CI&DEI - Centre for Studies in Education and Innovation
Viseu, Portugal
tgouveia@esev.ipv.pt

Rui Raposo
Departamento de Comunicação e Arte
Universidade de Aveiro
DigiMedia - Digital Media and Interaction Research Centre
Aveiro, Portugal
raposo@ua.pt

Nídia Salomé Morais
Departamento de Comunicação e Arte
Escola Superior de Educação de Viseu
CI&DEI - Centre for Studies in Education and Innovation
Viseu, Portugal
salome@esev.ipv.pt

***Abstract*— A rápida evolução da paisagem tecnológica desafia-nos a explorar novas formas de utilização das tecnologias, incluindo a Inteligência Artificial (IA) Generativa. Este artigo tem como objetivo analisar como os estudantes de mestrado percebem e aplicam a IA nas suas investigações académicas. O estudo, realizado através de um inquérito por questionário aplicado a estudantes de um mestrado na área da Comunicação, numa instituição de Ensino Superior em Portugal, revela que o uso de ferramentas de IA em atividades de investigação é escasso ou mesmo inexistente. Apesar dessa tendência dominante, alguns estudantes já experimentaram essas ferramentas em outros contextos. Os resultados destacam a oportunidade e a necessidade de desenvolver habilidades e literacia tecnológica nos alunos no que diz respeito ao uso de ferramentas digitais que envolvam soluções de IA, sem negligenciar a importância da promoção do pensamento crítico e do reconhecimento dos valores associados à ética digital. Prevê-se a realização de estudos semelhantes noutras Instituições de Ensino Superior e uma análise periódica para acompanhar as mudanças nas atitudes e práticas dos alunos em relação à IA na investigação académica. É fundamental promover a consciencialização sobre o potencial e os desafios associados ao uso da IA, a fim de preparar os alunos para a integração dessa tecnologia nas suas futuras carreiras académicas e profissionais. O estudo contribui para a compreensão inicial do papel da IA na investigação académica e destaca a importância de uma abordagem educacional que incentive a adoção responsável e ética das ferramentas de IA.**

Keywords— Inteligência Artificial, Ensino Superior, Investigação Académica, ChatGPT

I. INTRODUÇÃO

Quando Buckminster Fuller [1] criou o conceito de Ephemeralização em 1938, provavelmente não imaginava o quanto esse conceito faria sentido na era da Inteligência Artificial (IA). A IA teve a sua origem mais de uma década depois, em trabalhos de Alan Turing [2]. O conceito de Ephemeralização baseia-se na ideia de que o avanço da tecnologia permite-nos fazer cada vez mais com menos, eventualmente chegando ao ponto de fazer tudo com nada. Embora haja exceções, como problemas de cobertura de rede em dispositivos móveis, tanto a Ephemeralização quanto a ubiquidade tecnológica expressa por Kleinrock [3] mostram progressos ao longo do tempo. Recentemente, surgiram aplicações baseadas em IA que estão a causar disrupções e debates em áreas como a educação, a criação artística e direitos autorais.

Embora o interesse massificado na IA, especialmente com o ChatGPT, não tenha surgido simultaneamente com a sua génese, houve um aumento na atenção que lhe foi dada nos media e nas redes sociais, com artigos, programas de TV, debates e entrevistas com especialistas discutindo o ChatGPT e o seu potencial impacto no mundo. A facilidade de uso e rápida adoção desta tecnologia, permitindo que as pessoas façam perguntas simples mesmo sem conhecimento técnico, contribuiu para o aumento do número de utilizadores e a diversidade de perguntas feitas, alimentando, assim, o treinamento da ferramenta com grandes volumes de dados. Esse contexto despertou maior perceção e interesse sobre o impacto da IA, e é, agora, difícil encontrar uma instituição de ensino superior em Portugal que não tenha realizado sessões, debates ou seminários sobre o tema.

A regulamentação [5], o desenvolvimento de modelos de adoção da IA no Ensino Superior [6] e os debates sobre as visões utópicas ou distópicas da IA e o seu impacto na sociedade [7][8] têm adquirido relevância e interesse. É curioso observar que essas visões polarizadas deixam de fora uma terceira perspetiva, mais realista e alinhada com os fenómenos observados com o surgimento de tecnologias como as redes sociais e dispositivos móveis.

Toda a nova tecnologia traz consigo um conjunto de novas responsabilidades que são tão relevantes quanto as suas potencialidades. No entanto, é difícil prever o que acontecerá com a tecnologia, os utilizadores e a experiência resultante da interação entre ambos, devido à imprevisibilidade inerente ao ciclo de vida das tecnologias. A história do telemóvel ilustra bem essa imprevisibilidade, pois evoluiu além das suas funções iniciais, como fazer chamadas, para se tornar um dispositivo multifuncional que permite tirar fotografias, gravar vídeos e fornecer entretenimento.

A compreensão desse fenómeno, chamada de visão protópica por Kevin Kelly [9], reconhece que as novas tecnologias trazem tanto benefícios quanto desvantagens, nem sempre evidentes no início. No entanto, acredita-se que o estado atual sempre seja um pouco melhor do que o passado, mesmo com a emergência de tecnologias disruptivas como a IA.

O papel atual da Inteligência Artificial nas atitudes, perceções e práticas dos estudantes de mestrado em relação ao uso dessa tecnologia nas suas investigações académicas é uma questão ainda pouco clara. É necessário tempo e experiências acumuladas para obter uma compreensão mais completa e precisa dessa realidade. No entanto, de acordo com a revisão bibliográfica realizada, já existem alguns trabalhos de investigação e iniciativas concertadas que se têm debruçado sobre a integração da IA no ensino superior, explorando abordagens e ferramentas relacionadas à Inteligência Artificial em atividades de investigação académica.

II. IA NA INVESTIGAÇÃO ACADÉMICA: BENEFICIOS E DESAFIOS

É cada vez mais incontornável a importância da IA na investigação académica no ensino superior, revelando-se um campo multidisciplinar e promissor que exerce influência e estimula a produção de conhecimento e inovação. A compreensão das definições e dos conceitos que permeiam a inteligência artificial é de suma importância para uma abordagem crítica e proativa no contexto académico, abrindo horizontes para novas descobertas e desafios científicos.

A IA abrange uma ampla gama de conceitos e abordagens, tendo o potencial de revolucionar a forma como os computadores executam tarefas inteligentes que anteriormente eram exclusivas dos seres humanos [10]. A definição de IA abarca múltiplos conceitos que realçam a habilidade das máquinas em realizar tarefas inteligentes sem necessidade de programação explícita. Capacitando-as para a execução de tarefas específicas, a IA consiste num conjunto de tecnologias que facultam às máquinas aprender a partir de dados e experiências anteriores [11]. Essa abordagem, fundamentada no processo de aprendizagem e experiência, representa um progresso significativo no campo da IA.

A IA corresponde ao estudo minucioso de como os computadores podem realizar tarefas que anteriormente eram privilégio exclusivo dos seres humanos. E essa capacidade de imitar as atividades inteligentes humanas constitui um dos pilares fundamentais da IA. Graças a algoritmos e técnicas avançadas, os computadores são capazes de efetuar aprendizagem, raciocínio e previsões, assemelhando-se aos processos de pensamento e comportamento humano [12]. Ou seja, a IA tem como objetivo permitir que as máquinas realizem tarefas complexas de forma autónoma. A capacidade de imitar os processos cognitivos humanos, juntamente com a capacidade de aprendizagem e autonomia, possibilita que as máquinas enfrentem desafios e tomem decisões inteligentes [13]. Por isso, diversos estudos têm explorado as vantagens oferecidas pela IA em todas as etapas do processo científico, destacando-a como uma aliada essencial para otimizar a eficiência, precisão e qualidade das pesquisas académicas no ensino superior. Neste campo de ação, a IA tem sido amplamente discutida como uma poderosa ferramenta na escrita académica e nas publicações científicas, possibilitando melhorias significativas no trabalho académico, como a geração automática de resumos ou de traduções [10]. As ferramentas assistidas por IA têm demonstrado a sua utilidade na organização do material, na criação de esboços e na revisão de trabalhos, proporcionando maior eficiência e precisão aos investigadores [14]. Além disso, a IA desempenha um papel importante na escrita académica, auxiliando os autores na identificação de erros ortográficos e gramaticais, sugerindo palavras-chave relevantes e facilitando a busca por artigos relacionados [11].

A tecnologia de geração automática de texto, mesmo não sendo consensual, também tem sido destacada como uma forma de acelerar o processo de investigação e aumentar a produtividade dos investigadores, permitindo que se concentrem em tarefas mais complexas e criativas [15]. A automação de tarefas rotineiras e demoradas pela IA também liberta tempo para análises mais complexas dos dados [16]. A IA oferece benefícios adicionais na recolha e análise eficiente de grandes conjuntos de dados, identificação de padrões e geração automática de resumos [17]. Esta capacidade da IA em processar grandes quantidades de dados e identificar padrões complexos [18], impulsiona avanços em diversas áreas científicas [13].

Em suma, a inteligência artificial apresenta inúmeras potencialidades e benefícios para a investigação académica no ensino superior. A sua aplicação abrange desde a geração automática de resumos e traduções até à organização e revisão de trabalhos, incluindo a identificação de lacunas no conhecimento científico, análise de grandes conjuntos de dados, automação de tarefas rotineiras e identificação de padrões complexos. Essa revolução na forma como os investigadores conduzem as suas pesquisas resulta em maior eficiência, precisão e qualidade nos resultados obtidos.

Porém, a implementação da IA na investigação académica suscita uma série de questões e desafios que requerem uma reflexão criteriosa. Compreender adequadamente essas limitações é fundamental para assegurar a utilização responsável e eficaz da IA no contexto académico.

Diversos autores salientam a importância de um debate abrangente sobre as ameaças e as restrições associadas ao uso de ferramentas de IA na investigação académica [10]. Preocupam-se especialmente com o impacto na confiança e na integridade do trabalho académico, enfatizando a necessidade de cautela, transparência e adesão aos princípios éticos e académicos. Além disso, destacam preocupações éticas, tais como o risco de plágio e o viés algorítmico na escrita científica [14]. Ressalta-se, assim, a importância de equilibrar a IA com as competências humanas, a fim de preservar a ética e a transparência no processo criativo.

A precisão dos resultados gerados pela IA também é uma preocupação levantada por vários autores [19][15]. Estes investigam a frequência de "alucinação" da IA em propostas de investigação, o que suscita inquietações quanto à precisão dos dados gerados. Também enfatizam a importância de garantir resultados precisos e confiáveis, alertando para o risco de uma dependência excessiva dessas tecnologias. É, portanto, crucial manter um equilíbrio entre a automação proporcionada pela IA e as competências humanas necessárias para uma investigação académica eficaz.

No contexto da escrita científica, sublinham-se as limitações da tecnologia atualmente disponível em relação à complexidade desse tipo de escrita [11]. A obtenção de um conhecimento profundo do tema por parte dos autores é ainda necessário para garantir a precisão e a qualidade das informações. Alerta-se para o perigo de uma dependência excessiva nas ferramentas baseadas em IA, as quais podem levar à perda das competências críticas necessárias no processo de pesquisa e escrita. Adicionalmente, ressalta-se a importância de assegurar a responsabilidade dos autores mesmo quando utilizam recursos baseados em IA.

A validação humana é apontada como um fator crucial para garantir a qualidade das produções geradas pela IA em tarefas complexas, como a geração automática de resumos científicos [20]. Embora os resumos gerados pelo ChatGPT sejam semelhantes aos escritos por humanos em termos de estrutura e conteúdo, ainda existem diferenças subtis na linguagem e no estilo. Tal realça a importância de envolver a competência humana na validação desses resultados.

A IA também apresenta desafios específicos para a investigação qualitativa [16]. É fundamental garantir a qualidade dos dados recolhidos e analisados, pois os algoritmos podem ser influenciados por enviesamentos e erros nos dados. Ressalta-se que a automação na análise textual pode levar à perda de nuances importantes, uma vez que as máquinas não possuem a mesma capacidade que os seres humanos para interpretar o contexto e o significado das palavras. Substituir completamente a interpretação humana pelos resultados gerados pela IA pode negligenciar aspetos relevantes da investigação qualitativa.

A infraestrutura e o pessoal especializado são desafios apontados para a implementação bem-sucedida de sistemas baseados em IA [17]. Além disso, a qualidade dos resultados depende das informações utilizadas para treinar esses sistemas, o que pode afetar a sua precisão se essas informações estiverem enviesadas ou forem incompletas. A formação dos investigadores nas técnicas necessárias para utilizar eficientemente a IA também é fundamental.

Além disso, alerta-se para os efeitos negativos da aplicação irresponsável da IA na investigação científica [18]. Preocupações como enviesamentos algorítmicos, falta de transparência e riscos de privacidade são mencionadas. Essas questões éticas requerem uma regulamentação responsável da IA no âmbito da ciência.

Por fim, destacam-se a importância da qualidade dos dados de treinamento e da multidisciplinaridade para a implementação bem-sucedida da IA na investigação científica [13]. Salientam-se, igualmente, as preocupações éticas relacionadas à privacidade e segurança dos dados, além da necessidade de transparência nas decisões tomadas pelos sistemas baseados em IA.

Em suma, a revisão da literatura converge na necessidade de adotar uma abordagem cautelosa, transparente e ética no uso da IA na investigação académica. Os autores mencionados destacam desafios como a preservação das competências humanas, a validação humana, a qualidade dos dados de treinamento, a infraestrutura e formação adequadas, além das questões éticas envolvidas. Para maximizar os benefícios da IA, é essencial enfrentar essas limitações e desafios de forma responsável e consciente.

III. ESTUDO E PARTICIPANTES

O estudo apresentado neste artigo visa, especificamente, tentar compreender as atitudes, as perceções e as práticas de estudantes de mestrado em relação ao uso da IA no âmbito das suas investigações académicas. Pretende-se, assim, compreender o papel da IA em contextos de investigação e identificar os benefícios e os desafios associados. Metodologicamente, trata-se de uma pesquisa exploratória, no sentido em que se procura explorar um tema em particular (IA em contextos de investigação), de modo a que os resultados obtidos possam fornecer pistas e informações para futuras investigações dentro da área de estudo. O principal instrumento para a recolha de dados foi um questionário e participaram no estudo 13 estudantes de um mestrado na área da Comunicação de uma Instituição de Ensino Superior em Portugal, que concordaram responder de forma voluntária e consentida. O questionário contemplou 9 questões e foi implementado com recurso à ferramenta gratuita *Google Forms*. Depois de validado, foi divulgado junto dos estudantes inscritos no mestrado.

Em termos de participação, e conforme se pode observar no Gráfico 1, responderam 10 estudantes do sexo feminino e 3 do sexo masculino.

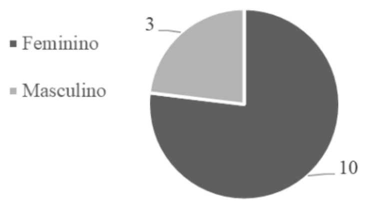


Gráfico 1. Género dos Participantes

No que se refere às idades dos estudantes (Gráfico 2), há a predominância da faixa etária entre os 23 e os 25 anos (7), seguindo-se os participantes que mencionaram ter entre 20 e 22 anos (3) ou 26 anos ou mais (3).

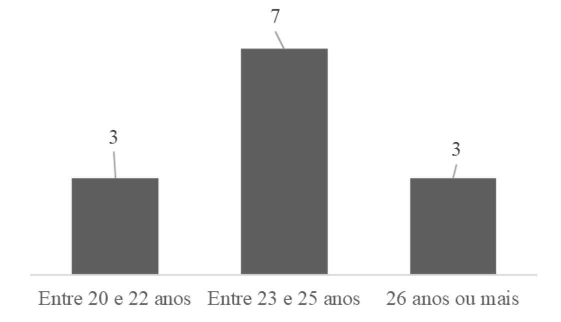


Gráfico 2. Idade dos Participantes

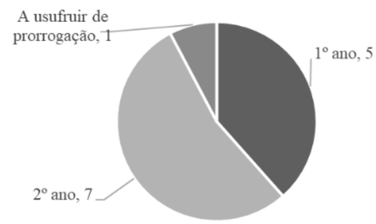


Gráfico 3. Ano em que os participantes se encontravam matriculados

Conforme se pode confirmar na figura anterior (Gráfico 3), as respostas dos alunos indicam que a maioria (7) frequentava o 2º ano do mestrado, uma grande parte (5) indicou estar a frequentar o 1º ano do curso e apenas 1 participante referiu que se encontrava a usufruir do prazo de prorrogação para a entrega do projeto final de mestrado.

Ao nível do envolvimento destes estudantes em atividades de investigação (Gráfico 4), denota-se que a maioria (7) já tinham experiência desde a licenciatura, seguindo-se os que mencionaram ter iniciado investigações académicas no 1º ano do mestrado (4).

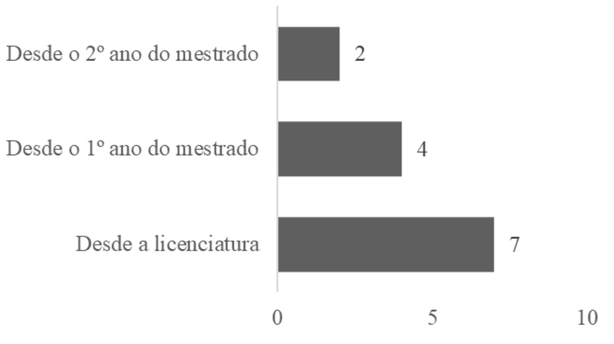


Gráfico 4. Envolvimento em atividades de investigação

IV. Discussão do Resultados

Questionados sobre a frequência de uso de IA em contextos de investigação, denota-se que a maioria dos estudantes nunca usou ou raramente recorreu a IA para desenvolver atividades relacionadas com as suas investigações (cf. Tabela I). A maioria dos participantes (11) assumiram que é raro ou inexistente o recurso a este tipo de ferramentas para realizarem mais rapidamente atividades ligadas à investigação, bem como raramente ou nunca as usaram para resolverem problemas ou para aumentarem a visibilidade da sua investigação.

Apesar de se observar que alguns alunos já recorrem a ferramentas de IA, a verdade é que se denota a mesma tendência de uso (raro ou inexistente) por grande parte dos alunos (9) em tarefas como a comunicação e colaboração com outros investigadores ou na exploração de novas questões e métodos de investigação.

TABELA I. Frequência de uso de IA na investigação

	1	*2*	*3*	*4*
	n	***n***	***n***	***n***
Realizar atividades ligadas à minha investigação de forma mais rápida	2	9	2	0
Facilitar a comunicação e a colaboração com outros investigadores	4	5	4	0
Ajudar na resolução de problemas na investigação	4	7	2	0
Explorar novas questões e métodos de investigação	3	6	3	1
Aumentar a visibilidade da investigação	5	6	2	0

Legenda: 1- Nunca; 2- Raramente; 3- Muitas Vezes; 4- Sempre

O Gráfico 5 apresenta as respostas dos alunos no que concerne às principais ferramentas de IA que usam nas suas investigações. De ressalvar que, nesta questão em particular, os participantes poderiam escolher até três opções.

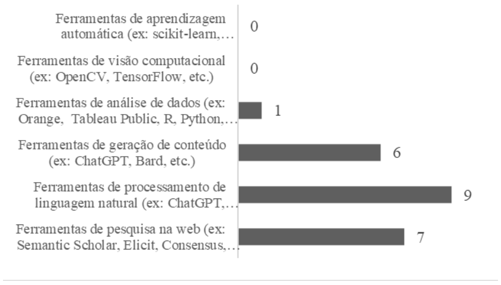


Gráfico 5. Ferramentas de IA usadas na investigação

Com efeito, denota-se uma inclinação da maioria (9 estudantes) para a utilização de ferramentas de processamento de linguagem natural, onde se incluem soluções como ChatGPT, ChatPDF, entre outros. O recurso a ferramentas de pesquisa na Web também é assumido por muitos participantes (7), assim como são vários os estudantes (6) que admitem ter experimentado soluções que permitem a geração de conteúdo (onde também se inclui o ChatGPT). Entre as ferramentas menos usadas encontram-se as que permitem a análise de dados, sendo que apenas 1 participante assinalou o seu uso. Os resultados obtidos mostram que nenhum estudante assinalou ter usado ferramentas de aprendizagem automática nem ferramentas de visão computacional.

Questionados sobre "Quais são as principais tarefas de investigação que costuma realizar com a ajuda de ferramentas de IA?", há uma clara tendência das respostas dadas para a opção "nunca usei" (cf. Tabela II). De facto, a grande maioria (10) revela nunca ter usado IA em tarefas ligadas à interpretação de resultados, sendo que também são muitos os estudantes (8) que assumem nunca terem recorrido a este tipo de ferramentas para as seguintes tarefas: análise de dados, escrita, revisão e/ou divulgação de artigo(s). Apesar de grande parte (6) nunca ter usado, há alguns (4) que admitem que já usaram IA e gostaram do resultado obtido em tarefas ligadas à revisão da literatura.

TABELA II. Tarefas de investigação e uso de IA

	1	*2*	*3*	*4*
	n	***n***	***n***	***n***
Revisão da literatura	6	3	4	0
Recolha de dados	6	2	2	3
Análise de dados	8	1	2	2
Interpretação dos resultados	10	1	1	1
Escrita de artigo(s)	8	3	1	1
Revisão de artigo(s)	8	2	3	0
Divulgação de artigo(s)	8	1	2	2

Legenda: 1- Nunca usei; 2- Já usei e não gostei do resultado; 3- Já usei e gostei do resultado; 4- Nunca usei, mas gostaria de usar

Também se confirma praticamente a inexistência de uso de IA em atividades de recolha de dados (6 alunos assinalaram nunca ter usado), contudo salienta-se que 2 estudantes já usaram e não gostaram do resultado; 2 estudantes já usaram e gostaram do resultado e 3 participantes nunca usaram, mas gostariam de vir a usar nesta tarefa em particular.

A perceção dos estudantes em relação aos principais benefícios do uso de IA na investigação não é clara, conforme se pode observar pelos dados da Tabela III, que revelam uma tendência de 'não concordo nem discordo" para a grande parte das opções.

TABELA III. BENEFÍCIOS ASSOCIADOS AO USO DE IA NA INVESTIGAÇÃO

	1	*2*	*3*	*4*	*5*
	n	*n*	*n*	*n*	*n*
Poupa tempo e recursos na investigação	1	0	5	6	1
Melhora a precisão e a confiabilidade da investigação	3	2	4	4	0
Amplia o alcance e a profundidade da investigação	1	2	4	5	1
Estimula a criatividade e a inovação na investigação	2	1	5	3	2
Facilita o acesso e a partilha do conhecimento na investigação	2	0	3	5	3

Legenda: 1- Discordo Totalmente; 2- Discordo; 3- Não concordo nem discordo; 4- Concordo; 5- Concordo Totalmente

O benefício em que a maioria mostrou maior concordância (5 concordaram e 3 concordaram totalmente) é o que sugere a facilidade no acesso e na partilha do conhecimento na investigação decorrente do uso de IA. Apesar de vários estudantes (5) não terem mostrado uma tendência clara, há muitos (7) que mostraram concordância em relação à afirmação que sugere que a IA "poupa tempo e recursos na investigação", sendo que também são muitos (6) que concordaram ou concordaram totalmente que a IA amplia o alcance e a profundidade da investigação.

A perceção de que o uso de IA estimula a criatividade e a inovação na investigação colheu a concordância de 5 participantes, contudo são também 5 os estudantes que não concordam nem discordam desta ideia. Por último, e apesar de serem vários (4) os que não conseguem decidir, há uma inclinação discordante (5 estudantes) no que se refere à possibilidade de a IA melhorar a precisão e a confiabilidade da investigação.

Sobre os principais desafios do uso da IA na investigação, os participantes poderiam eleger até três opções das elencadas no questionário. Conforme ilustra o Gráfico 6, a grande maioria considera que a falta de confiança ou transparência (10), bem como a falta de ética ou responsabilidade da IA na investigação (9) são desafios a considerar neste contexto. Também se observa que muitos estudantes (7) sentem que a falta de competências ou conhecimentos para usar IA na investigação pode ser também um desafio a ter em conta. Vários alunos assinalaram ainda a falta de apoio ou reconhecimento da IA (4) e a falta de qualidade ou relevância da IA na investigação (3) como outros dos desafios que devem ser considerados.

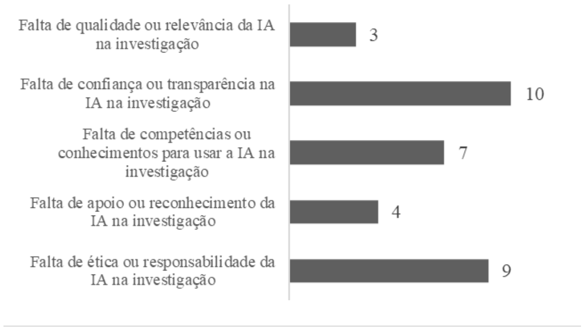


Gráfico 6. Principais desafios do uso da IA na investigação

Por último, questionaram-se os estudantes sobre o tipo de formação que gostariam de receber sobre o uso da IA na sua investigação (Gráfico 7), sendo que se denota um forte interesse em formações presenciais (7), na forma de workshops, seminários e conferências. Muitos alunos (5) também assinalaram como possibilidade a formação online, tais como cursos, webinars e tutoriais. Há ainda a registar que 1 participante referiu não ter interesse em receber formação sobre a temática.

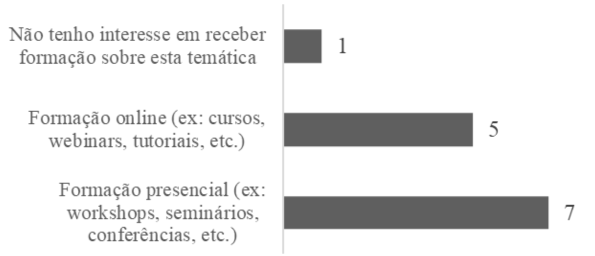


Gráfico 7. Tipo de formação sobre o uso da IA na investigação

V. CONCLUSÕES

O presente estudo permitiu construir uma perspetiva, embora com limitações evidentes que decorrem da amostra reduzida de participantes do questionário, sobre as atitudes, perceções e práticas dos estudantes de mestrado no que diz respeito à utilização da IA no contexto das suas investigações académicas. Não obstante ter-se recolhido respostas apenas de 13 participantes, os resultados revelam fortes indícios de uma rara ou inexistente adoção destas ferramentas de IA em contextos de investigação.

A esmagadora maioria dos inquiridos afirmou nunca ter utilizado IA nas tarefas relacionadas com as suas investigações académicas, sendo evidente um reduzido interesse em recorrer a esta tecnologia para a realização de tarefas específicas, tais como apoiar a revisão da literatura, a escrita ou a revisão de artigos, entre outras. Importa salientar que alguns estudantes já exploraram algumas das ferramentas mencionadas no questionário, embora não necessariamente no âmbito das suas próprias investigações, com particular destaque para as soluções de processamento de linguagem natural, como o ChatGPT, ChatPDF, entre outras.

Relativamente à identificação dos benefícios da utilização de IA em contextos de investigação, os resultados obtidos não permitem estabelecer uma tendência clara. Contudo, um dado relevante sugere a facilidade de acesso e partilha do conhecimento na investigação decorrente da aplicação da IA. Os resultados também evidenciam que, no que concerne aos desafios, existem perceções associadas à falta de confiança ou transparência nos resultados produzidos, assim como preocupações relacionadas com a ética e responsabilidade no uso da IA na investigação. Por último, a maioria dos participantes manifestou interesse em receber formação, seja em formato *online* ou presencial, sobre a utilização de ferramentas de IA na atividade de investigação académica.

Como um dos principais resultados deste estudo, destaca-se a identificação da oportunidade e necessidade de promover competências e literacia digital nos estudantes, no que concerne à utilização de ferramentas digitais que integram soluções de IA, sem descurar a importância de fomentar o pensamento crítico e o reconhecimento dos valores associados à ética digital. Projetam-se futuros estudos análogos em outras instituições de ensino superior em Portugal, bem como a repetição periódica deste estudo, com o intuito de analisar eventuais mudanças nas atitudes, perceções e práticas dos alunos.

Acknowledgment

This work is funded by National Funds through the FCT - Foundation for Science and Technology, I.P., within the scope of the project Refª UIDB/05507/2020. Furthermore we would like to thank the Centre for Studies in Education and Innovation (CI&DEI) and the Polytechnic of Viseu for their support.

References

[1] R. B. Fuller, "Nine Chains to the Moon: An Adventure Story of Thought." Berlin, Boston: Birkhäuser; 2019. p.267-270. https://doi.org/10.1515/9783035617764-035

[2] J. Moor, ed. "The Turing test: the elusive standard of artificial intelligence." Vol. 30. Springer Science & Business Media, 2003.

[3] L. Kleinrock, "An Internet vision: the invisible global infrastructure." Ad Hoc Networks. 2003 Jul 1;1(1), pp.3-11

[4] A. Oliveira, "A conversation with GPT-3 on COVID-19". (2020, April 26). Digital Minds. Consultado Abril 8, 2023, disponível em: https://digitalminds2016.wordpress.com/2020/07/26/a-conversation-with-gpt-3-on-covid-19/

[5] V. Koniakou, "From the "rush to ethics" to the "race for governance" in Artificial Intelligence". Information Systems Frontiers. 2023 Feb;25(1):71-102. https://doi.org/10.1007/s10796-022-10300-6

[6] UNESCO, "ChatGPT-and-Artificial-Intelligence-in-higher-education-Quick-Start-guide_EN_FINAL.pdf." (n.d.). consultado Abril 30, 2023, disponível em:https://www.iesalc.unesco.org/wp-content/uploads/2023/04/ChatGPT-and-Artificial-Intelligence-in-higher-education-Quick-Start-guide_EN_FINAL.pdf

[7] S. Cave, and K. Dihal, "Hopes and fears for intelligent machines in fiction and reality". Nature Machine Intelligence. 1. 2019, pp. 74-78. https://doi.org/10.1007/s10796-022-10300-6

[8] H. P. Bienvenido, B. Borja, and J. Mora-Fernandez. "A Historical Review of Immersive Storytelling Technologies." *Advances in Business Information Systems and Analytics*, 2021, pp. 569–97. https://doi.org/10.4018/978-1-7998-6985-6.ch027.

[9] K. Kelly, *What technology wants*. 2011, New York: Penguin Books.

[10] I. Dergaa, K. Chamari, P. Zmijewski, and H. Ben Saad, "From human writing to artificial intelligence generated text: Examining the prospects and potential threats of chatgpt in academic writing," *Biology of Sport*, vol. 40, no. 2, pp. 615–622, 2023.
https://doi:10.5114/biolsport.2023.125623

[11] M. Salvagno, F. S. Taccone, and A. G. Gerli, "Can artificial intelligence help for scientific writing?," *Critical Care*, vol. 27, no. 1, 2023. https://doi:10.1186/s13054-023-04380-2

[12] C. Zhang and Y. Lu, "Study on Artificial Intelligence: The state of the art and future prospects," *Journal of Industrial Information Integration*, vol. 23, p. 100224, 2021. https://doi:10.1016/j.jii.2021.100224

[13] Y. Xu *et al.*, "Artificial Intelligence: A powerful paradigm for scientific research," *The Innovation*, vol. 2, no. 4, p. 100179, 2021. https://doi:10.1016/j.xinn.2021.100179

[14] S. Altmäe, A. Sola-Leyva, and A. Salumets, "Artificial Intelligence in scientific writing: A friend or a foe?," *Reproductive BioMedicine Online*, 2023. https://doi:10.1016/j.rbmo.2023.04.009

[15] J. Y. Lee, "Can an artificial intelligence chatbot be the author of a scholarly article?," *Journal of Educational Evaluation for Health Professions*, vol. 20, p. 6, 2023. https://doi:10.3352/jeehp.2023.20.6

[16] L. Longo, "Empowering qualitative research methods in education with Artificial Intelligence," *Advances in Intelligent Systems and Computing*, pp. 1–21, 2019. https://doi:10.1007/978-3-030-31787-4_1

[17] N. Besimi, A. Besimi, and B. Cico, "Artificial Intelligence in Education and learning (AI in research)," *2022 11th Mediterranean Conference on Embedded Computing (MECO)*, 2022. https://doi:10.1109/meco55406.2022.9797216

[18] E. González-Esteban y Patrici Calvo, "Ethically governing artificial intelligence in the field of scientific research and Innovation," *Heliyon*, vol. 8, no. 2, 2022. https://doi:10.1016/j.heliyon.2022.e08946

[19] S. A. Athaluri *et al.*, "Exploring the boundaries of reality: Investigating the phenomenon of artificial intelligence hallucination in scientific writing through chatgpt references," *Cureus*, 2023. https://doi:10.7759/cureus.37432

[20] C. A. Gao *et al.*, *Comparing scientific abstracts generated by CHATGPT to original abstracts using an artificial intelligence output detector, plagiarism detector, and blinded human reviewers*, 2022. https://doi:10.1101/2022.12.23.521610

Bacia do Rio Doce - aspectos sócio-históricos, econômicos e ambientais: formação continuada híbrida no Projeto Rio Doce Escolar

Manoel Augusto Polastreli Barbosa
Secretaria de Educação de Conceição do Castelo
Prefeitura de Conceição do Castelo Conceição do Castelo
Conceição do Castelo – Brasil
0000-0003-1162-0670

Antonio Donizetti Sgarbi
Programa de Pós-Graduação em Educação em Ciências e Matemática
Instituto Federal do Espírito Santo
Vila Velha - Brasil
0000-0003-2955-3939

***Resumo*—O presente trabalho tem como objetivo apresentar o desenvolvimento da disciplina "Bacia do Rio Doce: aspectos sócio-históricos, econômicos e ambientais" no Curso de Pós-Graduação em Aperfeiçoamento em Metodologias de Educação Ambiental, assim como, no Curso de Pós-Graduação em Especialização em Educação Ambiental Escolar, ambos ofertados no formato híbrido. O estudo é classificado como qualitativo e exploratório. Seus participantes foram 363 alunos da disciplina, sendo eles, 73 alunos do curso de Especialização em Educação Ambiental Escolar, e, 290 alunos do curso de Aperfeiçoamento em Metodologias de Educação Ambiental. Entre as atividades desenvolvidas, estiveram: produção de um painel colaborativo com a ferramenta Padlet, construção da primeira etapa do Portfólio do Caminho do Projeto de Educação Ambiental, e, a apresentação dos aspectos sócio-históricos, econômicos e ambientais do território capixaba do Rio Doce com a produção de um varal colaborativo. O desenvolvimento da disciplina mostrou-se como um relevante ponto de partida para o processo formativo dos cursos de aperfeiçoamento e de especialização, considerando a ênfase proporcionada nos aspectos do cotidiano para uma reflexão crítica da realidade vivida no território, vivenciada através de potenciais momentos formativos compartilhados no Ambiente Virtual de Aprendizagem (AVA), juntamente ao encontro presencial para o fechamento do componente curricular.**

Palavras-chave*—*aperfeiçoamento, Educação Ambiental Crítica, especialização, formação de educadores ambientais.

I. Introdução

Diante do crime ambiental ocorrido em 5 de novembro de 2015 por meio do rompimento da Barragem da Samarco, localizada no complexo minerário de Germano, em Fundão, distrito de Mariana – MG, pertencente à Mineradora Samarco S.A., mantida pela Vale S.A. e a BHP Billiton, o Rio Doce foi atingido com uma pluma rejeitos de mineração de ferro no decorrer de toda a sua extensão até a sua foz no distrito de Regência, Linhares – ES, atingindo diversas comunidades e municípios, assim como, o comprometimento de diferentes ecossistemas [5].

Em decorrência do exposto, a Fundação Renova foi criada com o objetivo de executar medidas de reparação, restauração e recuperação por meio de programas socioeconômicos e socioambientais, sendo que um de seus projetos de reparação é o Programa de Educação para Revitalização da Bacia do Rio Doce (PG33), em conformidade com a Política Nacional de Educação Ambiental, o Decreto Regulamentador nº 4.281/2002, as deliberações do Comitê Interfederativo – CIF (Deliberações 136 e 240) e a Cláusula 172 do Termo de Transação e Ajustamento de Conduta [6] [14].

Entre uma das ações do PG33, constituiu-se o "Projeto Rio Doce Escolar: Formação de Educadores em Educação Ambiental nas Escolas Capixabas do Rio Doce", envolvendo o Instituto Federal do Espírito Santo (IFES), a Fundação de Apoio ao Instituto Federal de Educação, Ciência e Tecnologia do Espírito Santo (FACTO) e a Secretaria da Educação do Espírito Santo (Sedu), buscando uma formação em nível de pós-graduação de educadores com atuação em escolas públicas da Educação Básica dos quatro municípios situados no decorrer da Bacia do Rio do Doce no Estado do Espírito Santo (ES): Baixo Guandu, Colatina, Marilândia e Linhares, integrando ações e atividades de ensino, pesquisa e extensão [6].

Os quatro municípios do Estado do Espírito Santo que compõem a região da Bacia do Rio Doce englobam aproximadamente 296 escolas que ofertam a Educação Básica entre os segmentos: Ensino Médio, Ensino Fundamental – Anos Iniciais e Anos Finais, e Educação Infantil, sendo, três instituições escolares de dependência administrativa federal, 26 mantidas pelo governo estadual e 240 pelos governos municipais. O projeto foi criado com o objetivo de atender 50% das instituições escolares da região, o que contempla uma média de 140 escolas da região participando dos processos formativos em Educação Ambiental, envolvendo participantes de variados níveis formativos com ações práticas que gerem impactos reais para as comunidades escolares e o seu entorno, aproximando a realidade escolar em contexto interdisciplinar com o Projeto Político Pedagógico (PPP) das instituições escolares, culminando na construção de Planos de Intervenção Municipais (PIM) de Formação Continuada em Educação Ambiental [6].

A disciplina "Bacia do Rio Doce: aspectos sócio- históricos, econômicos e ambientais" compõe a matriz curricular dos cursos de Pós-Graduação em Aperfeiçoamento em Metodologias de Educação Ambiental e de Especialização em Educação Ambiental Escolar [7] [8]. Ambos os cursos são vinculados ao Projeto Rio Doce Escolar e ofertados pelo Instituto Federal do Espírito Santo – Campus Vila Velha.

A disciplina foi ofertada no primeiro semestre do ano de 2023 pelos autores do manuscrito, desenvolvida na Plataforma Moodle pelo Ambiente Virtual de Aprendizagem (AVA) - Centro de Referência em Formação e em Educação a Distância (CEFOR)/Instituto Federal do Espírito Santo (IFES), mantida em duas salas: uma direcionada ao curso de aperfeiçoamento e outra para o curso de especialização.

O componente curricular teve como objetivo "conhecer e discutir, na perspectiva da educação, a delimitação espacial e os aspectos sócio-históricos, econômicos e ambientais do território capixaba da Bacia do Rio Doce" [7] [8]. Sua ementa abordou as relações entre educação, realidade, interesses sociais e individuais, os aspectos sócio-históricos, econômicos e ambientais do território capixaba do Rio Doce, alguns aspectos da realidade local antes e após o rompimento da Barragem de Fundão e problemas gerais e específicos da parte capixaba da Bacia do Rio Doce [7] [8].

Deste modo, o presente trabalho tem como objetivo apresentar o desenvolvimento da disciplina "Bacia do Rio Doce: aspectos sócio-históricos, econômicos e ambientais" no Curso de Pós-Graduação em Aperfeiçoamento em Metodologias de Educação Ambiental, assim como, no Curso de Pós-Graduação em Especialização em Educação Ambiental Escolar, ambos ofertados no formato híbrido.

O estudo apresentado faz parte da pesquisa de Doutorado em andamento intitulada "Aspectos históricos e socioambientais do Rio Doce na formação de educadores ambientais do município de Baixo Guandu – ES" do Programa Pós-Graduação em Educação em Ciências e Matemática do Instituto Federal do Espírito Santo – Campus Vila Velha.

II. REFERENCIAL TEÓRICO

A Educação Ambiental nasce em resposta a um contexto de crise ambiental reconhecido no final do século XX, com vistas a possibilitar ao ser humano a adoção de uma visão de mundo e uma prática social eficazes na redução dos impactos ambientais [2] [9]. Todavia, notou-se que a Educação Ambiental se tratava de uma prática educativa complexa e multidimensional, englobando relações entre o indivíduo, a sociedade, a educação e a natureza, o que demandaria intensos e sucessivos aprofundamentos teóricos que contemplassem a amplitude que a envolve [9].

No contexto brasileiro, a Educação Ambiental se constitui como "[...] componente essencial e permanente da educação nacional, devendo estar presente de forma articulada, em todos os níveis e modalidades do processo educativo, em caráter formal e não-formal" [1] com a Lei nº 9.795 de 27 de abril de 1999, que institui a Política Nacional de Educação Ambiental (PNEA) em seu 2º artigo.

Em seu percurso histórico, ocorreu a busca por uma definição conceitual universal para a Educação Ambiental brasileira de forma que atendesse a todos os envolvidos nessa práxis educativa, entretanto, essa demanda é abandonada com o reconhecimento da pluralidade de visões existentes de atores que se dividiam em posicionamentos diferentes frente a esse universo [9]. Essa diversidade de concepções resulta em um campo de disputa hegemônico envolto de interesses diversos, perpassando desde às necessidades populares de emancipação, igualdade social e qualidade de vida, como os interesses do capital, do mercado, reforçados pelas classes dominantes [2].

Diversas são as definições apontadas para a Educação Ambiental na literatura [2], diferenciando-se em seus referenciais teóricos, políticos, práticos, pedagógicos e epistemológicos, por vezes, antagônicos e, até mesmo, adversários [9] [10]. Nessa multiplicidade conceitual, são discutidas três macrotendências político-pedagógicas no âmbito da convivência e da disputa hegemônica simbólica na Educação Ambiental brasileira: a conservacionista, a pragmática e a crítica [9].

A macrotendência crítica agrupa as vertentes da Educação Ambiental Popular, Emancipatória, Transformadora e no Processo de Gestão Ambiental, fundamentando-se na necessidade de se revisar criticamente as bases que proporcionam a dominação do ser humano e dos mecanismos de acumulação do Capital, enfatizando o enfrentamento político das desigualdades e reforçando a busca pela justiça socioambiental. Essa macrotendência se preocupa em politizar e contextualizar o debate ambiental como meio de trazer para o discurso as contradições existentes nos modelos de desenvolvimento e de sociedade [9].

Na macrotendência crítica da Educação Ambiental, têm- se um trabalho direcionado para a visão sistêmica de meio ambiente, pensado em sua totalidade complexa como um conjunto onde seus elementos e partes interdependentes mantêm relações entre si, entre as partes e o todo, o todo nas partes por meio de uma interação sintetizada no equilíbrio dinâmico [4].

Assume-se a Educação Ambiental Crítica como um processo de mudança no ambiente, relacionada com um posicionamento político de seus agentes sociais em relação a projetos para a sociedade e em busca da sustentabilidade [12]. Defende-se que as transformações ocorridas na sociedade são causa e consequência, por meio de uma relação dialética, da transformação de cada ser humano, havendo reciprocidade dos processos. Com isso, educando e educador constituem-se como agentes sociais transformadores, abertos para o meio no qual estão inseridos, para a comunidade e os problemas socioambientais, intervindo na realidade para que se sintam sujeitos em suas histórias de vida [4].

Deste modo, [2] traz para o diálogo a formação de educadores ambientais como fomentadores e dinamizadores, perpassando por diferentes espaços e buscando a conexão entre eles, de modo a criar uma rede conjunta de movimento constante e participativo, objetivando a quebra de bases que se distanciam da sustentabilidade e proporcionam o sentimento de pertencimento e de luta pelo território vivido.

A formação de educadores ambientais proposta por [2] propõe eixos principais como essenciais para o desenvolvimento de cada indivíduo: o exercício para a ruptura de armadilhas paradigmáticas, os momentos de vivências coletivas, o estímulo da percepção e compreensão do espaço educacional como movimento, a formação do educador ambiental enquanto liderança, o trabalho na linha construtivista da educação, a concepção do processo educativo em movimento de acordo com a realidade social, a valorização da autoestima do educador ambiental, a importância da relação para o processo de formação educacional, a sensibilização do educador ambiental enquanto interlocutor na articulação das diferentes áreas de conhecimento, o exercício da emoção e construção do sentimento de pertencimento ao coletivo, e, por fim, o estímulo a renúncia ao estabelecido e a ousadia para a inovação.

Nessa perspectiva, a formação de educadores ambientais precisa ser pensada a partir de uma perspectiva crítica, colaborativa, democrática, articulada e dialógica, de modo a romper com os movimentos conservadores e pragmáticos ainda existentes na sociedade e que não respondem as necessidades no que se relaciona a crise ambiental vigente.

Diante disso, diferentes possibilidades formativas são desenvolvidas de modo a atender as diversas demandas e contextos existentes na sociedade atual. São novos ambientes e dinâmicas de apropriação, divulgação e produção de informação, implementados com cada vez mais frequência e amplitude, rompendo com os limites geográficos e temporais por meio de diferentes linguagens [3].

As tecnologias digitais abrem caminho para potenciais atuações e caracterizando-se no âmbito da Educação Ambiental como um importante instrumento de atuação, mobilização de intervenção social, objetivando a obtenção de respostas às demandas da contemporaneidade. Este movimento se manifesta e entra em contraposição ao embate hegemônico ao almejar um sentido com maior criticidade quanto a Educação Ambiental, ocupando espaço e buscando a participação de pessoas e organizações que defendem ambientes de discussão das diferentes posições existentes na sociedade, estruturando e sendo estruturantes da realidade socioambiental [3].

III. MATERIAIS E MÉTODOS

O estudo é classificado como qualitativo e exploratório. Seus participantes foram 363 alunos da disciplina “Bacia do Rio Doce: aspectos sócio-históricos, econômicos e ambientais”. Os participantes da formação continuada de educadores ambientais, tanto do curso de Aperfeiçoamento em Metodologias de Educação Ambiental, quanto do curso de Especialização em Educação Ambiental Escolar, são professores, gestores e agentes comunitários, atuantes nas escolas públicas de Educação Básica dos municípios localizados na região da Bacia do Rio Doce no território do Espírito Santo:

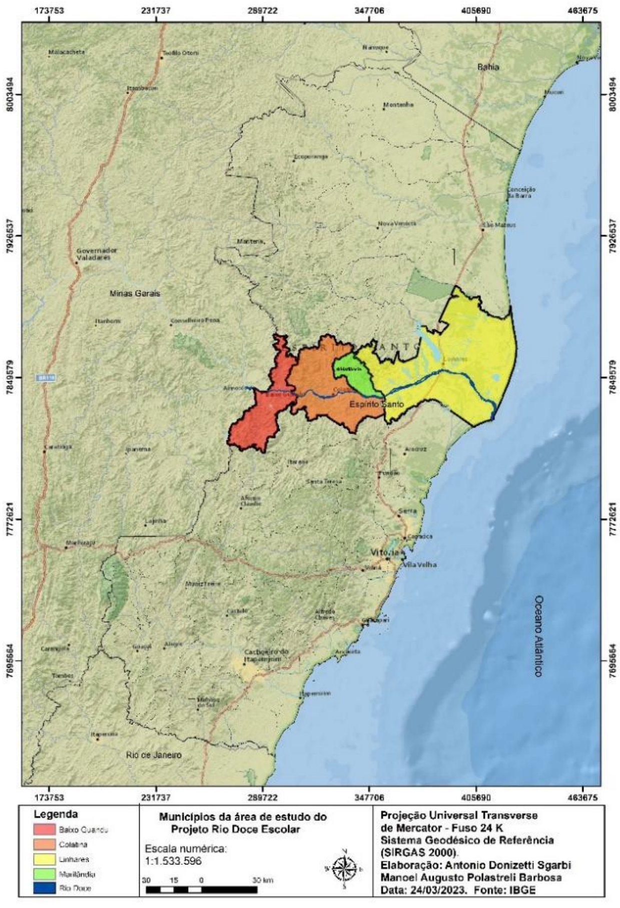


Fig. 1. Municípios da área de estudo do Projeto Rio Doce Escolar

O Projeto Rio Doce Escolar traz as propostas de dois cursos de formação continuada: o Curso de Aperfeiçoamento em Metodologias de Educação Ambiental e o Curso de Especialização em Educação Ambiental Escolar. Os cursos têm como foco o desenvolvimento de conteúdos, assimilando teoria e prática de pesquisa em programas e projetos da Educação Básica, com o objetivo de produzir coletivamente, no decorrer dos cursos, propostas de pesquisa e intervenção que traduzam a exigência da construção de relatos de experiência e artigos científicos [6].

O Curso de Aperfeiçoamento em Metodologias de Educação Ambiental apresenta teorias e práticas pedagógicas que podem ser desenvolvidas no espaço escolar, assim como ferramentas, metodologias e propostas didáticas que dialoguem com a Educação Básica [6]. Enquanto, o Curso de Especialização em Educação Ambiental Escolar é desenvolvido em dois módulos. O primeiro apresenta o mesmo itinerário formativo do Curso de Aperfeiçoamento em Metodologias de Educação Ambiental e será ofertado em articulação com este. O segundo módulo oferta disciplinas que visam o aprofundamento teórico da temática, objetivando a elaboração e execução de intervenção pedagógica de Educação Ambiental (Tabela I).

TABLE I. ORGANIZAÇÃO DO CURSO DE APERFEIÇOAMENTO EM METODOLOGIAS DE EDUCAÇÃO AMBIENTAL E DE ESPECIALIZAÇÃO EM EDUCAÇÃO AMBIENTAL

Componente Curricular			Carga Horária
Eixos	**Descrição**	**Modalidade**	
Módulo 1 (210h) Aperfeiçoamento e Especialização	Educação a Distância e Ambientação na Plataforma Moodle	On-line	15
	Bacia do Rio Doce: aspectos sócio-históricos, econômicos e ambientais	Híbrida	25
	Bacia do Rio Doce: aspectos geológicos e geomorfológicos	Híbrida	25
	Projeto Político Pedagógico e Educação Ambiental Crítica	Híbrida	15
	Debates em Ciência, Tecnologia, Sociedade e Ambiente (CTSA)	Híbrida	15
	Tecnologias Digitais no Contexto da Educação Ambiental	Híbrida	15
	Alfabetização Científica em Trilhas de MOOC’s	On-line	60
	Projetos de Educação Ambiental Escolar I	Híbrida	40
Carga horária total do curso de Aperfeiçoamento			210h
Módulo 2 (150h) Especialização	Currículo e Educação Ambiental	Híbrida	45
	Políticas Públicas em Educação Ambiental	Híbrida	45
	Cidadania ambiental	Híbrida	30
	Projeto de Educação Ambiental Escolar II	Híbrida	30
Carga horária total do curso de Especialização			360h

Fonte: os autores (2023) baseados em [7] [8].

Devido ao quantitativo do público participante, os alunos foram organizados em quatro turmas na Especialização em Educação Ambiental Escolar e em doze turmas no Aperfeiçoamento em Metodologias de Educação Ambiental.

A divisão ocorreu com o agrupamento de alunos de acordo com os seus respectivos municípios de atuação: Baixo Guandu, Colatina, Linhares e Marilândia. Cada turma foi identificada por um código específico no Ambiente Virtual de Aprendizagem (Tabela II).

TABLE II. ORGANIZAÇÃO DE TURMAS DA DISCIPLINA BACIA DO RIO DOCE: ASPECTOS SÓCIO-HISTÓRICOS, ECONÔMICOS E AMBIENTAIS

Curso	Código/Grupo	Alunos
Especialização em Educação Ambiental Escolar	422507 – Colatina	19
	422515 – Colatina	19
	422523 – Linhares	17
	438920 – Linhares	18
Aperfeiçoamento em Metodologias de Educação Ambiental	422395 - Baixo Guandu	21
	422411 – Colatina	28
	422419 – Colatina	27
	422427 – Colatina	26
	422451 - Linhares	31
	422459 - Linhares	25
	422467 - Linhares	24
	422475 - Linhares	23
	422483 - Linhares	23
	422491 - Linhares	22
	422499 - Marilândia	28
	442409 - Linhares	12
Total		363

Fonte: os autores (2023).

Para a avaliação da disciplina, foi aplicado um questionário pelo Google Forms composto de quatro questões, sendo: duas objetivas e duas discursivas, com a finalidade de identificar o perfil do público respondente e os apontamentos avaliativos quanto ao desenvolvimento da disciplina.

IV. RESULTADOS E DISCUSSÕES

O desenvolvimento da disciplina se deu de forma híbrida com a abordagem dos seguintes conteúdos e divisões:

TABLE III. CONTEÚDOS EAD E PRESENCIAL DA DISCIPLINA BACIA DO RIO DOCE: ASPECTOS SÓCIO-HISTÓRICOS, ECONÔMICOS E AMBIENTAIS

Formato	Conteúdos	Carga Horária
On-line	Povos originários do Vale do Rio Doce: educação, território e ambiente.	22 horas
	Vale do Rio Doce: colonização, imigração, industrialização e degradação socioambiental.	
	Aspectos sociais da Bacia do Rio Doce antes e depois do rompimento da Barragem de Fundão.	
Presencial	Entrelaçamentos do contexto socioambiental do território da Bacia do Rio Doce capixaba.	3 horas
Total		25 Horas

Fonte: os autores (2023).

Entre as atividades desenvolvidas, estiveram a produção de um painel colaborativo por meio da ferramenta digital Padlet. Os cursistas trouxeram um aspecto sócio-histórico, econômico e/ou ambiental do território capixaba do Rio Doce identificado por eles nos arredores de suas escolas de atuação. Os educadores ambientais em formação utilizaram de diferentes recursos para a apresentação: textos, imagens, podcasts, vídeos etc. Foi solicitado aos cursistas que tivessem um registro em formato de imagem para posterior apresentação no encontro presencial (Figura 2).

Fig. 2. Padlet produzido pela turma do Curso de Aperfeiçoamento em Metodologias de Educação Ambiental do Município de Baixo Guandu – ES

Neste primeiro momento, os educadores ambientais compartilharam diferentes aspectos presentes no contexto vivido que influenciam direta ou indiretamente seus modos de vida no território capixaba do Rio Doce. Com isso, a produção do Padlet possibilitou uma multiplicidade de discussões entre cidadãos de um mesmo território, compartilhando saberes, vivências, necessidades e até mesmo denúncias. Conforme aponta [3] ao discutir a utilização do meio virtual para a formação de educadores ambientais, utilizamos deste espaço para traduzir ações e discussões numa interface aberta para novas e diversas conexões entre saberes e sujeitos, possibilitando a ruptura com a previsibilidade, a pré-determinação e a homogeneização mocultururalizante, transformando-o em uma dinâmica organizativa, tanto de mobilização social, quanto de produção de conhecimento [3].

Na segunda atividade, os cursistas produziram a primeira etapa do Portfólio do Caminho de construção do Projeto de Educação Ambiental, abordando os aspectos sócio-históricos, econômicos e ambientais da comunidade escolar na qual estão inseridos. Trata-se de um documento construído no decorrer dos cursos de Aperfeiçoamento em Metodologias de Educação Ambiental e de Especialização em Educação Ambiental Escolar.

A terceira e última atividade consistiu na apresentação dos aspectos sócio-históricos, econômicos e ambientais do território capixaba do Rio Doce identificados pelos cursistas nos municípios de suas escolas de atuação. No momento de apresentação, foi disponibilizado o tempo máximo de três minutos para cada cursista. Para esse encontro de finalização, pediu-se aos alunos que levassem uma imagem impressa que representasse a situação analisada, para a montagem de um varal colaborativo. Como forma de registro, solicitou-se que fotografassem a apresentação no dia do encontro presencial e realizassem a postagem no Moodle.

Cada um dos professores realizou falas iniciais sobre a oferta da disciplina, os conteúdos desenvolvidos e a experiência obtida no decorrer de sua realização. Cada professor se direcionou a um dos polos de apoio presencial, um para a cidade de Colatina e outro para Linhares, de modo a acompanhar o momento de encontro com os cursistas (Figura 3).

Fig. 3. Aula presencial com montagem e apresentações do varal colaborativo - Polo Colatina

Após as falas iniciais dos professores, foram abertas as apresentações dos educadores ambientais, onde, por meio de suas falas e imagens trazidas, expuseram cada aspecto escolhido ligado ao Rio Doce, seja ele, histórico, social, econômico ou ambiental (Figura 4 e 5).

Fig. 4. Aula presencial com montagem e apresentações do varal colaborativo – Polo Colatina

Fig. 5. Aula presencial com montagem e apresentações do varal colaborativo - Polo Linhares

O processo avaliativo do componente curricular ocorreu através dos formatos EaD e presencial, onde, inicialmente, avaliou-se a participação no Fórum com montagem de Padlet e o envio de arquivo com documento composto por aspectos sócio-históricos, econômicos e ambientais do território onde a escola de atuação está localizada. No segundo momento, os alunos foram avaliados quanto a participação e apresentação dos aspectos sócio-históricos, econômicos e ambientais do território capixaba do Rio Doce.

Após a finalização da disciplina, os 363 alunos foram convidados a responder um formulário de avaliação da disciplina de modo a compreender os impactos trazidos com o desenvolvimento do componente curricular. Neste momento, obtivemos a participação de 244 cursistas nos dois questionamentos levantados: “Qual (is) ponto (s) abordados na disciplina de Bacia do Rio Doce: aspectos sócio- históricos, econômicos e ambientais você considera como mais relevante (s) para sua formação/atuação?” e “De que forma você considera que a discussão trazida sobre os aspectos históricos e socioambientais pode contribuir para sua formação/atuação?”.

Entre os participantes, estiveram 23 cursistas do município de Baixo Guandu, 65 alunos de Colatina, 133 alunos de Linhares e 23 alunos de Marilândia, sendo 161 alunos de aperfeiçoamento em Metodologias de Educação Ambiental e 63 alunos da especialização em Educação Ambiental Escolar. Alguns excertos dos cursistas são apontados abaixo sobre os pontos abordados na disciplina como relevantes para a formação/atuação:

TABLE IV. PONTO (S) ABORDADOS NA DISCIPLINA “BACIA DO RIO DOCE: ASPECTOS SÓCIO-HISTÓRICOS, ECONÔMICOS E AMBIENTAIS” DESTACADOS PELOS CURSISTAS COMO RELEVANTE (S) PARA A FORMAÇÃO/ATUAÇÃO

Cursista	Relato
C33[a]	“Os impactos causados pelo rompimento da barragem de Mariana nas comunidades ribeirinhas da Bacia Hidrográfica do Rio Doce.”
C61	“Conhecer um pouco da história dos nossos ancestrais indígenas como Krenak, Pataxó e Botocudos.”
C63	“O painel colaborativo, foi agregado valores e saberes diferentes vividos no cotidiano de cada grupo e pessoa.”
C64	“A descoberta de informações novas durante a pesquisa para a elaboração do portfólio.”
C170	“A história da colonização do Vale do Rio Doce, os relatos das fundações das cidades, as comunidades indígenas.”

[a] Inicial da palavra cursista acompanhado de numeração do participante

Fonte: os autores (2023).

Diante dos excertos selecionados, ressalta-se os impactos trazidos com o desenvolvimento da disciplina, ressaltando as questões locais, principalmente, de cunho histórico, ligados ao povo indígena e ribeirinho do território do Rio Doce. Destaca-se a contribuição do painel colaborativo, o Padlet, desenvolvido em uma das propostas avaliativas, como recurso tecnológico digital potencial para a promoção de reflexões coletivas e críticas em momentos formativos.

Além disso, ressalta-se a relevância dos recursos midiáticos utilizados na disciplina para o compartilhamento da história da colonização do território do Rio Doce, das fundações das cidades capixabas afetadas pelo crime ambiental e das comunidades indígenas. Por fim, aponta-se a importância de propostas de cunho investigativo como ponto de partida para a produção de novos saberes/conhecimentos locais.

Em relação ao segundo questionamento, os cursistas foram convidados a trazer apontamentos sobre as contribuições do componente curricular para as suas respectivas formações/atuações:

TABLE V. CONTRIBUIÇÕES DAS DISCUSSÕES SOBRE OS ASPECTOS HISTÓRICOS E SOCIOAMBIENTAIS NA FORMAÇÃO/ATUAÇÃO DOS CURSISTAS PARTICIPANTES DO PROJETO RIO DOCE ESCOLAR

Cursista	Relato
C1	"Na construção de um novo pensar e olhar diferenciado para o lugar onde eu vivo."
C17	"Os aspectos históricos trazem o passado para confrontar o presente e projetar o futuro. A partir dessa conjectura, acredito que nossas aulas estarão melhor embasadas para as projeções futuras e a ênfase necessária nas escolhas catastróficas dos nossos antepassados na temática meio ambiente."
C21	"A discussão fundamentada nos aspectos históricos e socioambientais ,nos proporciona uma percepção complexa e totalizadora da nossa realidade local (Bacia Hidrográfica do Rio Doce) nos possibilitando a construção ou reconstrução de conhecimentos significativos acerca da nossa realidade. Portanto, as formas com que as temáticas abordadas estão dispostas no referido curso está sendo crucial para a minha formação."
C127	"Retratando a história da maneira mais próxima de como ela aconteceu, aliado ao resultado por todo massacre, tanto antropológico como ambiental cometido, me causou um mal estar que a primeiro momento se manifestou em revolta (o que foi inevitável), e após transmutar essa energia, agora ela é o combustível para a elaboração e uma nova abordagem metodológica de ensino que resgate a cultura valorizando o meio ambiente."
C239	"A contribuição para o letramento e o desenvolvimento de consciência política em prol da construção de uma sociedade democrática, ecológica e socialmente sustentável."

Fonte: os autores (2023).

Com base nos relatos apresentados acima, nota-se as contribuições das discussões trazidas no componente curricular relacionadas a relevância dos aspectos históricos e socioambientais para a formação crítica dos cursistas. Denota-se as reflexões quanto aos conhecimentos, acontecimentos e saberes compartilhados e, consequentemente, as possíveis contribuições em suas respectivas atuações, engajados com a constituição de uma sociedade mais democrática e sustentável.

Espera-se que este processo formativo tenha contribuído para o reconhecimento da complexa teia social que necessita ser transformada [11], além da compreensão da não neutralidade quanto aos processos sociais ao qual a educação se articula intencionalmente diante das diferentes contradições existentes na sociedade, buscando de forma dialógica, a produção de conhecimentos que balizam a emancipação cidadã [13].

V. CONSIDERAÇÕES FINAIS

O desenvolvimento da disciplina "Bacia do Rio Doce: aspectos sócio-históricos, econômicos e ambientais" mostrou-se como um relevante ponto de partida para o processo formativo dos cursos de aperfeiçoamento e de especialização. Desde seu objetivo até as propostas de atividades colaborativas elaboradas, enfatizou-se nos aspectos do cotidiano para uma reflexão crítica da realidade vivida no território, envolvendo as questões históricas, sociais, ambientais e econômicas do Bacia do Rio Doce. A partir das avaliações da disciplina, destaca-se os apontamentos quanto as possibilidades de reflexão proporcionadas para a formação crítica e emancipatória dos sujeitos envolvidos, esperando repercussões em seus espaços de atuação formais e não-formais no decorrer do território do Rio Doce.

AGRADECIMENTOS

À Prefeitura de Conceição do Castelo - ES pelo apoio à Formação Continuada de Professores. À Prefeitura de Baixo Guandu - ES pelo apoio ao desenvolvimento da pesquisa. Ao Projeto Rio Doce Escolar, ao Programa de Pós-Graduação em Educação em Ciências e Matemática (EDUCIMAT), ao Instituto Federal do Espírito Santo – Campus Vila Velha e à Fundação de Amparo à Pesquisa e Inovação do Espírito Santo (FAPES) pelo apoio à pesquisa.

REFERÊNCIAS

[1] BRASIL. Lei n. 9795, de 27 de abril de 1999. Política Nacional de Educação Ambiental. Disponível em: <http://www.planalto.gov.br/ccivil_03/Leis/L9795.html> Acesso em: 19 dez. 2022.

[2] GUIMARÃES, Mauro. A formação de educadores ambientais. Campinas – SP: Papirus, 2004.

[3] GUIMARÃES, Mauro; SOARES, Ana Maria Dantas; CARVALHO, Néri Andréia Olabarriaga; BARRETO, Marcos Pinheiro. Educadores ambientais nas escolas: as redes como estratégia. Caderno Cedes, v. 29, n. 77, p. 49-62, 2009.

[4] GUIMARÃES, Mauro. Por uma Educação Ambiental Crítica na sociedade atual. Margens, v. 7, n. 9, p. 11-22, 2013.

[5] IBAMA. Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis. Laudo Técnico Preliminar: impactos ambientais decorrentes do desastre envolvendo o rompimento da barragem de Fundão, em Mariana, Minas Gerais. IBAMA: Brasília, 2015.

[6] IFES. Instituto Federal do Espírito Santo – Campus Vila Velha. Programa Rio Doce Escolar: Formação de Educadores em Educação Ambiental nas Escolas Capixabas do Rio Doce. Formulário de apresentação de plano de trabalho. PG33-Programa de Educadores para Revitalização da Bacia do Rio Doce. IFES: Vila Velha – ES, 2021. 56 p.

[7] IFES. Instituto Federal do Espírito Santo – Campus Vila Velha. Projeto Pedagógico de Curso de Aperfeiçoamento em Metodologias de Educação Ambiental. Vila Velha – ES: IFES, 2022a.

[8] IFES. Instituto Federal do Espírito Santo – Campus Vila Velha. Projeto Pedagógico de Curso de Pós-graduação Lato Sensu Especialização em Educação Ambiental Escolar. Vila Velha – ES: IFES, 2022b.

[9] LAYRARGUES, Philippe Pomier; LIMA, Gustavo Ferreira da Costa. As macrotendências político-pedagógicas da EA brasileira. Ambiente & Sociedade, v. 17, n. 1, p. 23-40, 2014.

[10] LOUREIRO, Carlos Frederico Bernardo. Complexidade e dialética: contribuições à práxis política e emancipatória em Educação Ambiental. Educação & Sociedade, v. 26, n. 93, p. 1473-1494, 2005.

[11] LOUREIRO, Carlos Frederico Bernardo. Educação Ambiental e Epistemologia Crítica. Revista Eletrônica do Mestrado em Educação Ambiental, v. 32, n.2, p. 159-176, 2015.

[12] LOUREIRO, Carlos Frederico Bernardo. Educação Ambiental: questões de vida. São Paulo: Cortez, 2019.

[13] LOUREIRO, Carlos Frederico Bernardo. Pensamento crítico, tradição marxista e a questão ambiental: ampliando os debates. In: LOUREIRO, Carlos Frederico Bernardo. (org.) A questão ambiental no pensamento crítico: natureza, trabalho e educação. Rio de Janeiro: Quartet, 2007.

[14] UNIÃO et al. Termo de Transação e de Ajustamento de Conduta – TTAC. Brasília, 2016. 119 p. Disponível em: http://www.meioambiente.mg.gov.br/images/stories/2016/DESASTRE_MARIANA/CIF/ACORDO_-_FINAL_-_ASSINADO.PDF. Acesso em 22 out. 2022.

CLASS TYPE PREFERENCES IN INFORMATICS ENGINEERING: BEFORE, DURING, AND AFTER THE PANDEMIC

Cristina Chuva Costa
Polytechnic Institute of Coimbra, ISEC
CISUC— Department of Informatics Engineering, University of Coimbra
Coimbra, Portugal
anabela@isec.pt

Anabela Gomes
Polytechnic Institute of Coimbra, ISEC
CISUC— Department of Informatics Engineering, University of Coimbra
Coimbra, Portugal
anabela@isec.pt

***Abstract*— The Covid 19 pandemic had a significant impact on different sectors of society. In the particular case of higher education, most of the classes transitioned to work remotely during the various lockdowns. The literature identifies several constraints associated with this change, especially in courses where students lacked technological skills or when there was a significant reliance on face-to-face interactions. Developing countries experienced serious difficulties due to deficient technological resources. Despite these challenges, it is also relevant to understand the added value of this configuration and how it can meet students' expectations, even outside of a pandemic context. With this aim, we conducted an analysis in Portugal on the transition to the remote/hybrid model during the confinements and its implementation based on the feedback of students of a technological course (Bachelor in Informatics Engineering). While some drawbacks were identified, particularly in terms of social and psychological aspects, it was also evident that these students reacted positively to certain strategies adopted during this period, which they deemed relevant for a post-COVID scenario. This study reinforces the notion that the current predominantly face-to-face teaching system needs to be reconsidered to incorporate solutions and configurations that, once experienced, can persist within the system, despite potential institutional and political resistance to their official adoption.**

Keywords—emergency remote teaching, technical background, class typology

I. INTRODUCTION

The first documented case of Covid-19 was identified in Wuhan, China, in early December 2019. The World Health Organization declared an international public health emergency on January 30, 2020. Due to the perceived risk, many governments have put in place various protective measures to control disease transmission [1], [2]. The United Nations Educational, Scientific, and Cultural Organization (UNESCO) reported in March 2020 that lockdowns and massive school closures had affected 87% of the world's students [3]. In July 2020, it increased to 98.6% - 1.725 billion children and youth, from pre-primary to higher education, in 200 countries that suffered educational disruptions [4].

The aforementioned temporary shift of instructional delivery to an alternative mode due to crisis circumstances is designated by Emergency Remote Teaching [5], [6]. These authors highlight that emergency remote teaching is not the same as well-planned and designed online learning, as it involves a rapid response to a crisis without prior preparation or infrastructure for remote instruction.

Remote teaching can encompass various forms, such as online courses, virtual classrooms, video lectures, interactive multimedia materials, discussion forums, and remote access to educational resources. It offers several advantages: flexibility (students can access course materials and lessons at any time and from anywhere); accessibility (it provides access to education for individuals who may face barriers in traditional classroom settings); enhanced technology integration; self-paced learning; and cost and time savings [7] [8]. However, it places technical demands on students and institutions, such as requiring a reliable Internet connection, access to devices, digital literacy skills, and ensuring security as well as privacy. These requirements must be considered to ensure that everyone involved has the necessary resources and support to effectively engage in their pursuits [9], [10], [11], [12].

In Portugal, the first wave of the pandemic forced all schools to suspend face-to-face classes on March 12, 2020. Within one week, due to the extraordinary effort of students and both academic and administrative staff, the education system was compelled to reinvent itself. It was able to offer digital alternatives to the scheduled on-campus academic activities. The on-campus lectures were mainly offered as live-streamed plenary lectures, with theoretical classes lasting for 50 minutes and two-hour practical classes. Most institutions used the video conferencing tool Zoom or Microsoft Teams to support these activities. The first lockdown lasted until the end of the 2019/2020 academic year, and the 2020/2021 school year began with a series of constraints, with no common solution being adopted at a national level. However, due to the high spread of the disease, a second confinement was decreed on January 15 and the remote/hybrid model ended up being adopted by most institutions until the end of the 2nd semester. During this period, the students had the chance to choose between face-to-face or remote classes.

Although the polytechnic has implemented security mechanisms, including distancing measures, alternate circulation routes, and disinfection materials, the majority of students chose to continue learning remotely. In addition to the learning benefits mentioned above, we believe that students with a technical background possess a proficiency in technology that enables them to adapt quickly to new technologies. Therefore, their feedback can provide a valuable contribution to evaluating the effectiveness and viability of remote learning models [13] and help identify strategies that can be refined and integrated into future teaching approaches in a pandemic or post-pandemic scenario. The students addressed in our study were enrolled in the bachelor's degree program in Informatics Engineering (2nd year) and answered the survey in the 2nd semester of 2020/2021 after experiencing two confinements. Obviously, this population has a bias towards students in general. However, for this very reason, it is important to understand the specifics of their profile.

The remainder of this paper is structured as follows: section 2 describes the research methodology adopted. Then, in section 3, we describe and analyse the research results. Finally, in section 4, we present the conclusions and discuss future research.

II. STUDY

In June 2021, we conducted a survey among students aimed at understanding their preferences regarding different educational scenarios. This paper specifically focuses on their preferences for classes during periods of confinement, like the one they experienced, as well as their projections for a 'normal' future situation.

The sample consisted of 116 students from the bachelor's degree program in Informatics Engineering (102 from the general regime and 14 from the post-work regime), in a total of 107 males and 9 females. The student's enrollment years vary substantially from 2009/2010 to 2019/2020. However, approximately 70% of the students are from 2019/2020 and have an average of 2 enrollments.

A. Technological resources

Several studies pointed out that students in developing countries faced several challenges in adopting remote learning during the Covid-19 pandemic, namely: limited access to technology, with many lacking the necessary devices, unequal access to the Internet due to limited or unreliable infrastructure, as well as power outages and unreliable electricity [14].

In our study, a significant majority of students already had access to the Internet in their homes before Covid. After the lockdown, there was a slight increase in conditions, as represented in the graph (Fig.1).

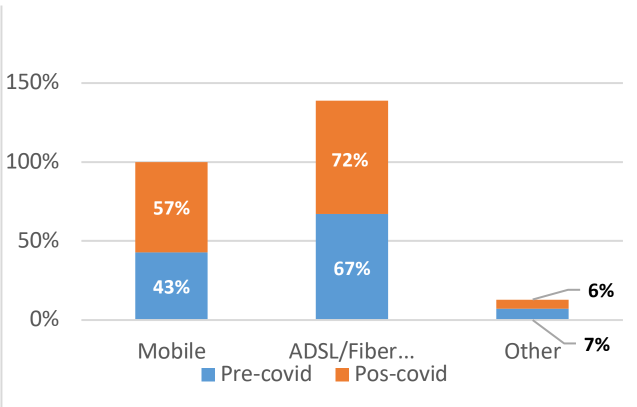


Fig. 1. Pre-covid and Pos-covid: Internet access at home

Concerning the devices used before the confinement, the students mostly used computers (tower or laptop). However, they also used smartphones regularly. The ones that had tablets tended to use them less. After the pandemic, the percentage of ownership and use of all mentioned devices increased slightly. The following graph (Fig. 2) details this information.

Based on the data obtained in this study, it is possible to verify that the students gathered the technological resources necessary to shift to remote teaching. Therefore, this factor did not negatively influence its adoption.

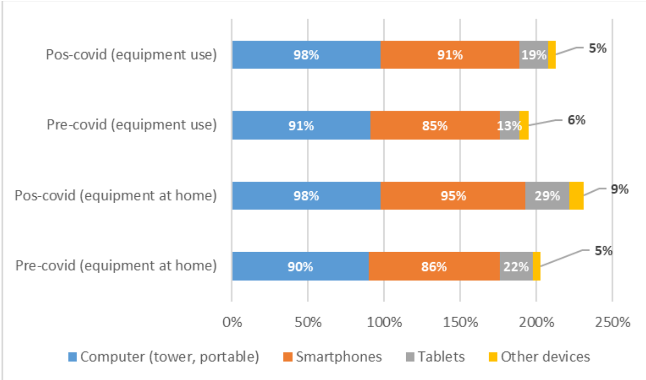


Fig. 2. Pre-covid and Pos-covid: Types of devices

B. Class type preferences

Two questions were asked without referring to the classes' typology (theoretical or practical).

Firstly, the question asked was, "**In times of normality, assuming you have all the conditions and possibilities of choice, what is your preferred class type? Why**?" The students distributed their preferences almost evenly between the hybrid system (47.5%) and face-to-face (44%). Only a small percentage of students (17.2%) answered online-only teaching.

Secondly, **the same question** was posed to students, but they were asked to project their answer considering **the covid lockdown period** (assuming a high rate of cases). As a result, we observed that the students' preferences also fell between two systems. This time, 50% referred they prefer the online system and 46.6 % the hybrid system. Face-to-face classes only received 3.4% of preferences. The results of these two questions are illustrated in Fig. 3.

The factors mentioned for this change in behaviour, showing the preference for online, were: the risk of leaving home (51.7%), safety in the classroom (44%), technical conditions available for remote classes (38.8%), economic factors (house payment, transport, purchase of material (37.1%), cohabitation with individuals at risk (34.5%), technological knowledge (22.4%), and others (10.3%). Among the students who referred that they prefer in-person classes, the motives were: being able to discuss exercises with colleagues, clarify doubts at the end of the class, socialize, and reach higher levels of concentration, opposed to online where it is very easy to be distracted. In their opinion, being at home makes one more "relaxed" ("not even having to change clothes") and not so attentive to the class. In short, they considered the face-to-face method the most effective for teaching and learning. The reasons for online preference were: family support, critical when they are part of the risk group;

the fact that the theoretical classes have greatly increased their quality since they shift to online, allowing the balance with working hours. Students who expressed their preference for the hybrid system highlighted that it promotes better learning outcomes due to its ability to combine the advantages of both systems.

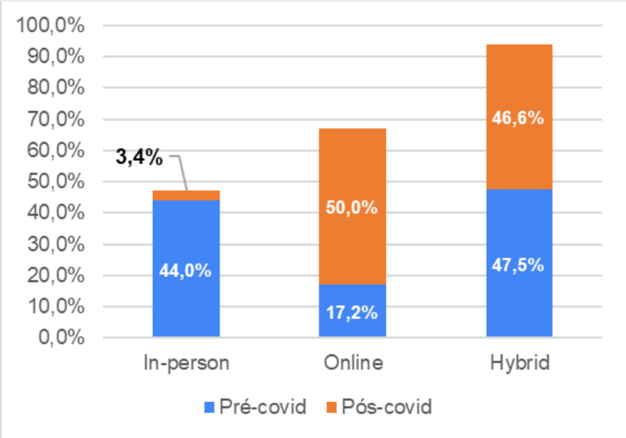


Fig. 3. Pre-covid and Pos-covid: Preferred type of classes

Subsequently, two additional questions were posed to students during a pandemic situation in order to project their preferences for a normal situation. These questions were asked separately for each class type, namely theoretical and practical.

Considering the question "**What typology of Theoretical classes would you prefer in a situation of a Post-Covid quarantine**? **Indicate the main positive and negative aspects**", the answers were roughly balanced between online (40,5%) and in person (37,9%), with 9,4% students who did not answer or gave vague answers.

The reasons given for the online preference were:

- Commuting time and cost savings: avoiding spending on transport and accommodation;
- Flexibility and convenience: the chance to wake up later; ability to access the Internet at any time; convenience and pragmatism of the whole situation; seems to be an individual class making it easier to understand; and better control over notes;
- Enhanced learning experience: best sound quality in class (noise reduction, which is not possible in a classroom with many students); the number of students does not influence the quality of the classes; clear visibility of teacher's shared content; screen sharing with slides/presentations is more readable and easier to interpret;
- Review and resource accessibility: availability of online class video recordings for reviewing concepts.

The negative aspects indicated and associated with this modality were: less time with colleagues; meeting fewer people; having extra expenses on computer equipment; lowest concentration; the lack of equipment for some people to attend this type of class.

The students point out the following reasons for the in-person preference: generate better-defined routines; promote best concentration/less distraction; improve teacher/student communication; a stronger relationship with peers and teachers; improvements in information capture; the existence of enhanced solutions for the teacher to explain; the greatest ease of learning; less tiring classes; improved communication and interaction; greater concentration allowed by the organisation of a routine imposed by fixed times. The students indicated only a negative aspect of this modality, the dislocation.

The reasons given for the hybrid preference were: the possibility of better accommodating the excessive number of students; the chance of meeting the various preferences of students, as long as they are allowed the option of choosing in person or online; and the possibility of adapting to the needs of different curricular units.

Concerning the question "**What typology of practical classes would you prefer in a post-covid situation?** Indicate the main positive and negative aspects", the answers to this question were in favour of the face-to-face regime (59,5%). In comparison, the online regime (12,9%) and the hybrid regime (17,2%) received significantly lower preferences. 10,3% of the students either did not respond or gave vague responses. The reasons given were similar to the preferences for theoretical classes and are presented below.

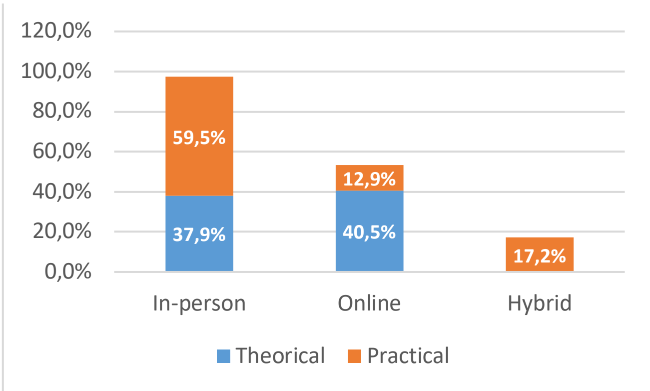


Fig. 4. Pos-covid: Preferred type of classes

The reasons given for the online preference were:

- Cost Savings: avoiding unnecessary travel, being practical and saving money.
- Increased convenience: more comfort and convenience, including not needing to wake up so early; to have access to search the Internet at any time;
- Improved quality of projections: to be able to see what the teacher is sharing clearly.
- Enhanced Learning: promoting greater autonomy in learning and facilitating deeper conceptual understanding.
- Improved quality of the lessons through technological integration: greater ease in following and understanding the materials/presentations thanks to the usage of technology. Students stated that "Sometimes in classrooms, there were many people and the teacher was not understood" or "sometimes teachers pay more attention to the students who sit in front and speak only to them".

As negative factors, the following were mentioned: less time with colleagues, getting to know fewer people; extra spending on classroom support equipment; more demand; reduced concentration; less interaction in the class; lack of "field" experience; the rhythm of the class being constantly broken to clarify doubts that the teacher would be able to answer individually without pausing the class for everyone.

The reasons provided for preferring in-person classes were as follows:

- Greater concentration/less distraction: offers a higher level of focus and reduced distractions. Students perceive that they are more attentive during in-person classes;
- Better communication between teacher and student: enables clearer and more effective communication, increasing classroom dynamics, interactivity, and engagement during lessons;
- Deeper relationships with peers and teachers: fosters stronger connections;
- Superior class quality: more profitable and productive classes, with a quality superior to that perceived in remote alternatives;
- Better clarification of doubts and closer follow-up: enables immediate clarification of doubts and questions, making students feel that they receive more assistance and support from teachers;
- Deeper learning: facilitates deeper understanding, especially in practical situations. It is particularly advantageous for hands-on activities, such as assembling devices and circuits, improving teaching and learning outcomes.

Regarding the negative aspects of in-person classes, the students mentioned the need to travel and the lack of recorded lessons, which greatly help when studying for exams.

The reasons given for the hybrid preference were:

- Reconciling interests: allows for a compromise between those who prefer online and face-to-face classes;
- Variation in effectiveness: adaptability of some topics to work better in an online format, while others benefit from in-person instruction;
- Reducing inequalities: helps address financial disparities, as it allows more students to participate regardless of their economic conditions;
- Improved quality of projections: enhances the quality of projections and visual aids due to the use of technology;
- Addressing class size issues: helps resolve problems related to oversized classes, avoiding situations such as arriving at class and not finding available seats;
- Flexibili ty and optimisation: allows for flexibility and optimises the use of resources based on the nature of each course;
- Easy transfer of digital information: offers the advantage of facilitating the seamless transfer of digital data between students and teachers.

III. Discussion

A. Comparative Analysis of Class Preferences

We can see that during the Covid quarantine, the preferences for class types changed in contrast to the pre-pandemic era by comparing the percentages of students who favoured each class type (online, in-person, or hybrid) during the Covid quarantine and in a post-Covid scenario.

It is clear from the data that during the Covid quarantine, people preferred online lessons more than in-person ones (mostly due to health and safety concerns), whereas the opposite was true for in-person sessions. It is clear from the information supplied that the choice for online classes increased during the Covid quarantine (mainly for health safety reasons). In contrast, the preference for in-person classes decreased significantly.

The hybrid system's preference was relatively stable during the Covid quarantine but was not explicitly mentioned in the post-Covid preferences.

Naturally, having these answers obtained during the pandemic phase, the students' perceptions may differ from those in a normal situation. When students are asked to project their preferences for later cases after eliminating a situation of confinement and suffering, this perspective may even be of some balance that does not correspond to a real desire in a normality condition. This can currently be seen, with a decrease in attendance, with a preference for a system other than face-to-face.

B. Factors Influencing Class Preferences

The mentioned factors for class preferences highlight the students' concerns for their health and well-being, as well as the availability and suitability of technological resources for remote learning.

The danger of leaving home has the most influence on students' preferences during the Covid quarantine, suggesting worries about possible virus exposure when attending in-person sessions. The perceived safety and lower risk of infection associated with online learning are preferred, which is also shown by the security in the classroom. These aspects of the technical environment confirm the accessibility and usefulness of technology resources for taking online courses. These aspects show how worried the students are about their physical and mental health, as well as how readily available and appropriate technology tools are for distance learning.

C. Positive and Negative Aspects of Different Class Typologies

Because of their accessibility, convenience, and ease of searching and reviewing material, online classes were favoured. They were also popular since they prevented needless travel and were safer. In turn, classes that were held in person were preferred because of their social and interactive elements, improved teacher-student interaction, and practical learning opportunities that weren't possible online. Hybrid classrooms were cited as advantageous for allowing for a range of tastes, offering flexibility, and perhaps lowering class sizes.

Overall, ease and accessibility were identified as advantages of online programs, but social connection and hands-on learning experiences were highlighted as advantages of in-person classes. The disadvantages of each modality were generally connected to its restrictions, such as the diminished social connection in online classrooms and the possible interruptions brought on by dislocation in in-person sessions.

These results shed light on how students view various teaching methods and might guide choices about structuring and running classes in diverse contexts.

IV. Classroom recommendations

Here are some suggestions for future classes based on the conclusions and findings already mentioned:

1. Adaptability & Flexibility: Recognize how easily students can change their minds about the classes they want to take. Give students the opportunity to select the type of class that best matches their requirements, whether online, in-person, or hybrid. Flexibility enables students to participate fully in their learning by accommodating a variety of preferences and situations.
2. **Health and Safety Measures:** Priority must always be given to the health and safety of students and teachers, ensuring the necessary protections for face-to-face classes. It is important to maintain a safe classroom environment in accordance with hygiene guideline and to address potential health concerns. Any situation of students or teachers who are at risk or prefer distance learning for health reasons must always be present and considered as possibilities for online alternatives.
3. **Technological Resources and Infrastructure:** Recognize the significance of technology infrastructure and resources for facilitating remote learning. Make sure students can access reliable Internet connections, the required equipment, and sufficient technical assistance. Institutions should invest money in technology that improves online learning and encourage productive communication and teamwork.
4. **Balancing Convenience and Engagement**: Strive to retain participation and connection while acknowledging the accessibility and convenience of online education. Investigate novel approaches to encourage student participation in online settings, such as interactive platforms, online group activities, and regular communication channels. Strike a balance between practicality, as well as worthwhile and meaningful educational opportunities and learning experiences.
5. **Integration of Social Interaction and Practical Experiences:** Recognize the importance of Social Interaction and Practical Experience in Education. Include socialising, teamwork, and hands-on learning opportunities in both traditional classroom settings and online courses. Utilise technology to aid classroom conversations, group projects, and hands-on learning exercises.
7. **Continuous Evaluation and Improvement:** Based on feedback from and experiences with students, continuously assess and enhance the efficacy of various teaching modes. Gather input from the students on their preferences, difficulties, and ideas for improving the learning environment. Use this feedback to inform decision-making and make necessary adjustments to meet and make the required modifications to accommodate the evolving needs of students.

These recommendations aim to create a student-centered learning environment that considers students' preferences, health, and learning outcomes. By considering these factors, educators and institutions can design future classrooms that cater to students' diverse needs and preferences, while ensuring the quality and effectiveness of the learning experience.

V. Conclusions and Future directions

The impact of Covid on everyday life, the economy, education systems, and other sectors is undeniable. Although confinements and health restrictions have ended, it is impossible to go back and pretend that nothing happened. Everyone has experienced situations related to the pandemic that have left marks on how people work, relate to others, acquire goods, or teach/study. While some areas have been negatively affected in terms of work contexts (such as healthcare and productive industries), those related to technology have embraced the "new normal". For example, software development companies continue to rely on remote/ hybrid work and e-commerce sales, as well as technological devices industries continue to grow.

During the lockdowns, most classes in higher education transitioned to a remote/hybrid mode. In this article, we present a study that addresses this transition, particularly focusing on the type of classes that students prefer before, during and after the pandemic in a higher education institution in Portugal. The scope of our research covers students of a technological course, Bachelor in Informatics Engineering. This choice aimed to capture the perception formed by this particular type of student, who possesses high digital skills and, in most cases, has access to technological resources. This allows us to focus the research on the teaching mode itself, rather than potential constraints for their functioning.

When asked about their preferred class type in a situation of normality, the student's responses were divided between face-to-face classes and hybrid systems, with a smaller percentage choosing online-only teaching. However, when considering the pandemic lockdown period, the preference shifted more towards online and hybrid systems, reflecting the concern for safety, technical conditions, economic factors, and individuals at risk. On the other hand, some students still preferred in-person classes due to the ability to discuss exercises with colleagues, socialise, and maintain better concentration compared to online classes.

Regarding theoretical classes, the student's preferences were evenly split between online and in-person formats during the post-COVID quarantine. The reasons for online preference included commuting time and cost savings, flexibility and convenience, enhanced learning experience, and review and resource accessibility. Negative aspects mentioned for online classes included less time with colleagues, extra expenses on computer equipment, and lower concentration levels. In contrast, the students who preferred in-person classes highlighted the benefits of routines, improved concentration, better teacher-student communication, stronger relationships with peers and teachers, and ease of learning. Commuting time and cost savings was the only negative aspect mentioned for in-person classes.

For practical classes, face-to-face classes received the highest preference, with students emphasising the advantages of greater concentration, better communication with teachers, deeper relationships with peers and teachers, superior class quality, and enhanced clarification of doubts. The hybrid system was seen as a way to reconcile interests, adapt to different topics, reduce inequalities, address class size issues, and optimise resources.

Based on the conducted study, it is evident that there is no single preference among students, highlighting the importance of organisations offering flexible solutions that respect individuality. It is necessary to recognise a tendency for theoretical classes to operate in person and remotely, creating numerous challenges for higher superior institutions. It is important (even for strategic reasons) to give students the opportunity to select the type of class that best matches their requirements, whether it be online, in-person, or hybrid. This allows students to choose their preferred mode of attendance for each session or activity and enables them to participate fully in their learning by accommodating a variety of preferences and situations. For instance, synchronous sessions can be conducted in person or through live online sessions, allowing students to engage in real-time discussions and interactions. Asynchronous materials, such as recorded lectures, online resources, and discussion forums, enable students to learn at their own pace and review content as needed.

The dynamism of such an adaptive scenario makes it extremely complex, giving rise to future research directions. It is important to investigate the following aspects in remote learning for technology courses: (1) effective pedagogical strategies, including the design and implementation of interactive and engaging online activities that promote active learning and critical thinking; (2) techniques and interventions to enhance student engagement and motivation in remote technology courses, such as gamification, peer collaboration, and personalised learning approaches; (3) the effects of remote learning on the social and emotional well-being of technology students, with a focus on interventions to foster a sense of belonging, connection, and support in virtual learning environments.

Acknowledgement

The authors would like to thank all students who participated in the study.

References

[1] L. Zhang and Y. Liu, "Potential interventions for novel coronavirus in China: a systematic review ," *J Med Virol*, vol. 92, no. 5, pp. 479–490, 2020.

[2] E. J. Sintema, "Effect of COVID-19 on the Performance of Grade 12 Students: Implications for STEM Education," *Eurasia Journal of Mathematics, Science and Technology Education*, vol. 16, no. 7, 2020, Accessed: Jun. 18, 2023. [Online]. Available: https://doi.org/10.29333/ejmste/7893

[3] UNESCO, "UNESCO Rallies International Organizations, Civil Society and Private Sector Partners in a Broad Coalition to Ensure #learningneverstops," 2020. [Online]. Available: https://en.unesco.org/news/unesco-rallies-internationalorganizations-civil-society-an d-private-sector-partnersbroad; accessed 23 June 2020

[4] United Nations, "Policy brief: Education during COVID-19 and beyond," 2020. [Online]. Available: https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/08/sg_policy_brief_covid-19_and_education_august_2020.pdf

[5] C. Hodges, S. Moore, B. Lockee, T. Trust, and A. Bond, "The Difference between Emergency Remote Teaching and Online Learning," *EDUCAUSE Review*, 2020, [Online]. Available: https://er.educause.edu/articles/2020/3/the-difference-between-emergency-remote-teaching-and-online-learning

[6] G. Cowden, P. Mitchell, and P. Taylor-Guy, "Remote learning rapid literature review," 2020. [Online]. Available: https://doi.org/10.37517/978-1-74286-610-9

[7] A. Bozkurt *et al.*, "A global outlook to the interruption of education due to COVID-19 pandemic: Navigating in a time of uncertainty and crisis," *Asian Journal of Distance Education*, vol. 15, no. 1, pp. 1–126, 2020.

[8] I. E. Allen and J. Seaman, "Changing Course: Ten Years of Tracking Online Education in the United States," 2013.

[9] S. J. Daniel, "Education and the COVID-19 pandemic," *Prospects (Paris)*, vol. 49, no. 1–2, pp. 91–96, Oct. 2020, doi: 10.1007/s11125-020-09464-3.

[10] M. M. Bishnoi and S. Suraj, "Challenges and Implications of Technological Transitions: The Case of Online Examinations in India," in *2020 IEEE 15th International Conference on Industrial and Information Systems (ICIIS)*, IEEE, Nov. 2020, pp. 540–545. doi: 10.1109/ICIIS51140.2020.9342655.

[11] G. A. Abrosimova, "Digital Literacy and Digital Skills in University Study," *International Journal of Higher Education*, vol. 9, no. 8, p. 52, Oct. 2020, doi: 10.5430/ijhe.v9n8p52.

[12] V. Mathew and E. Chung, "University Students' Perspectives on Open and Distance Learning (ODL) Implementation Amidst COVID-19," *Asian Journal of University Education*, vol. 16, no. 4, p. 152, Jan. 2021, doi: 10.24191/ajue.v16i4.11964.

[13] D. A. Swanson and C. S. Swanson, "Comparing Course Delivery Methods, What Do Students Prefer and What Works," in *52nd Annual Meeting of the Association Supporting Computer Users in Education (ASCUE)*, Myrtle Beach, SC, Jun. 2019.

[14] Q. Ali *et al.*, "Exploring the Students' Perceived Effectiveness of Online Education during the COVID-19 Pandemic: Empirical Analysis Using Structural Equation Modeling (SEM)," *Behavioral Sciences*, vol. 13, no. 7, p. 578, Jul. 2023, doi: 10.3390/bs13070578.

Integration of Large Learning Models into Higher Education: A Perspective from Learners

Katerina Zdravkova
Faculty of Computer Science and Engineering
Ss. Cyril and Methodius University
Skopje, N. Macedonia
katerina.zdravkova@finki.ukim.mk

Fisnik Dalipi
Faculty of Technology
Department of Informatics
Linnaeus University
Kalmar, Sweden
fisnik.dalipi@lnu.se

Fredrik Ahlgren
Faculty of Technology
Department of Computer Science and Media Technology
Linnaeus University
Kalmar, Sweden
fredrik.ahlgren@lnu.se

***Abstract*—Large language models (LLMs) are being criticized for copyright infringement, inadvertent bias in training data, a danger to human innovation, the possibility of distributing incorrect or misleading information, and prejudice. Due to their popularity among students, the introduction of many comparable apps, and the inability to resist unfair and fraudulent student usage, their educational use needs to be adapted and harmonized. The incorporation of LLMs should be defined not only by pedagogues and educational institutions, but also by students who will actively utilize them to learn and prepare assignments. In order to find out what students from two universities think and suggest about LLMs use in education, they were asked to give their contribution by answering the survey that was conducted at the beginning of the spring semester of academic 2022/23. Their feedback was quantitatively and qualitatively analyzed, showing in a better light what students think about LLMs and how and why they would use them. Based on the analysis, the authors propose an original strategy for integrating LLMs into education. The proposed approach is also adapted for those students who are not interested in using LLMs and for those who prefer the hybrid mode by combining their own research with LLMs generated recommendations. The authors expect that by implementing the proposed strategy, schools will benefit from a better education in which research, creativity, academic honesty, recognition of false information, and the ability to improve knowledge will prevail.**

Keywords—AI learning tool, ChatGPT, large language models, academic integrity, students' feedback, higher education.

I. Introduction

For centuries, traditional teachers opposed new educational technologies, while students have enthusiastically embraced and secretly used them whenever possible. David Baron claims that even writing was initially met with suspicion [1]. Moreover, teachers did not allow pencils with erasers, arguing that students would work better and more thoughtfully without the opportunity to do revisions [1].

The slide rule seems to be "arguably one of the most controversial pieces of education technology to enter the classroom" [2]. While their supporters went to extremes, proposing the abolition of pen-and-paper arithmetic [3], the fiercest opponents argued that calculators could have a detrimental effect on the development of mathematical skills [4]. Even the US College Board banned them but a decade later revised the attitude by mandating their use on exams [2].

Distance and open education received the support of UNESCO back in 1969, so the impression of teachers all over the world could not influence their integration [5]. Nevertheless, teachers' impressions were generally rather unfavourable in the beginning, reacting to, among other factors, increased workload, insufficient technical skills, a lack of interaction, and unsatisfactory administrative support [6]. The most conservative reaction was that it would cause a "McDonaldization of education" [7]. As controversial as it was earlier, remote education has become the only rescue for safe and unobstructed education during the COVID-19 pandemic [8] for all students, including those with various disabilities [9].

Modern learning and teaching cannot be imagined without the existence of technology and without using its growing potential in education [10]. As of November 30, 2022, a notable new player in the field emerged, embodied by ChatGPT [11]. It has encouraged other technology giants developing deep learning-based applications to intensify their efforts and launch own LLMs, generating many opportunities and challenges for education [12]. The students at the universities of the authors of this paper embraced the LLMs with enthusiasm. Recognizing the allure of prohibited tools and the counterproductive effects of banning LLMs, we propose an approach to integrate LLMs into education as painlessly as possible, without punishing those students who are not keen on using them. The strategy was shaped according to student feedback, including the long-term pedagogical experience of the authors of the text and their willingness to improve education by incorporating technological innovations.

The paper continues with the following sections: Section 2 provides an overview of the challenges of LLMs, with particular emphasis on their educational use. Section 3 starts with the three research questions based on the content of the student survey. It continues by presenting the methodological approach that introduces the sample and test instruments as well as the sampling technique and the study sample. Section 4 is dedicated to survey analysis and discussions. Each multiple-choice question is quantitatively assessed, while the open-ended questions are analyzed using Delve® qualitative data analysis software tool. The conclusion sublimates the motivation, challenges, and recommendations of integrating LLM into education and suggests the implications and recommendations of this new approach in education with the hope that it will improve the educational process and contribute to a better and academically honest way of doing home assignments.

II. Challenges of Large Language Models

Large language models employ deep learning methods and massively large data sets to comprehend, condense, produce, and anticipate new content [12]. Deep learning, as a subfield of AI imposes almost all its challenges to LLMs, including:

- The risks to human rights due to spyware revelations, violated people's right to privacy, failure of due diligence, discrimination in general, generation of discriminatory data, inadequate use of biometric technologies, insufficient transparency, use without restrictions, borders and supervision [13];
- Intellectual property protection, which embraces: the protection of inventors and their ownership, patent eligibility of AI-generated inventions, the degree of inventiveness and non-obviousness that are the main prerequisite of patentability, the necessity to disclose technology to enable a reproduction of the invention, the authorship and ownership that can be copyrighted, the copyright and confidentiality status of the data used for training the AI applications, the possibility to govern the ownership of AI-generated designs and to protect data and AI applications by trade secrets, the risks of intellectual property infringements [14, 15];
- The risk to increase unemployment and inequality at work caused by the automation of jobs in the coming decades, changing the demand for certain skills and increasing the inequality between different groups of workers [16];
- Generation of fake news and videos, which lead to the creation of impactful messages and content, massive spread of disinformation, deliberate shaping of humans' perceptions and influencing public opinion [17];
- Deepening of political, social and economic conditions by causing a digital divide, undermining the role of technology in initiating appropriate digitization [18];
- Crafting malicious codes, helping cyber criminals steal sensitive data, attack computer systems, or scripting phishing emails [19].

Aware of all these and many more challenges AI brings, in November 2021, UNESCO adopted a global agreement on the ethics of artificial intelligence [20]. The first progress report will be presented in December 2023. Since the adoption of the UNESCO agreement, LLMs have progressed significantly, creating a storm of negative and positive reactions. With the ability to generate different contents, they have a huge impact on education. In addition to numerous opportunities, LLMs create various challenges, which were exhaustively elaborated by Kasneci et al. [12]. We agree with the points of this outstanding paper and take the liberty to add some more that were discussed with our students during face-to-face interviews, which were organized prior to the survey.

The first challenge is that LLMs can cause the so-called Google effect [21] or digital amnesia, i.e., quickly forgetting the information that is available using the search engines. Because of the availability of a huge amount of instantly generated LLMs content, students will lose the desire to do their own research, reducing the ability to think critically, believing that information is objective even when common sense tells them that it is completely illogical. The insufficient transparency of the LLMs contributes to the impression that some information is of dubious credibility.

The goal of essay assignments is to contribute to the acquisition of new knowledge and encourage research and creativity. Brad Hughes [22] explains that this is an excellent opportunity to teach students to organize their ideas, to logically work out a problem, to make explicit connections, to argue facts, and to fit the arguments into the context of previous research. Regardless of the ingenuity of the question posed to the LLMs, if students take the answer for granted, do not read the answer carefully, and do not check its relevance, none of these goals and intentions will be achieved. Most of the practical assignments of our students are related to programming and programming tools. Here too, LLMs proved to be outstanding experts for writing codes, debugging, and optimizing them [11]. It is true that even now students abundantly scrape the solution from numerous open-source repositories [23] and submit them as their own solutions. Instead of acquiring skills, they learn patterns and if they expect to get them in the exam, they memorize them, but they are not able to create them from scratch. If they don't understand how the LLMs generated code works and how they can integrate it into their solution, they won't be able to do the tasks during the summer internship, and they won't be able to manage at work after graduation.

Despite these negative impacts, most institutions do not prohibit them, but secondary schools shouldn't use them [24]. The International Baccalaureate accepts LLMs from March 1, 2023, if they are expressly acknowledged as a source of information [25]. Springer, the journal and conference proceedings publisher, allows their usage [26]. After such encouraging news, we guided our students to utilize LLMs under our circumstances.

III. Methodological Approach

The existing body of research highlights various challenges associated with LLMs in the realms of academic writing and programming [27, 29-30]. Despite the growing interest in the use of generative AI models like ChatGPT for educational purposes, there is limited research on the experiences of learners using these tools for course-related text generation. This research gap is particularly relevant given the increasing reliance on online learning and the potential impact of AI tools on students' learning experiences and academic integrity. To understand the impact of LLMs, specifically the ChatGPT to educational activities, and how students perceive its implications, we seek answers to the following research questions (RQs):

- **RQ1:** *What is the awareness and familiarity of students regarding ChatGPT and other LLMs?*
- **RQ2:** *What is the motivation for using LLMs, and what attitudes students have towards the LLMs-based results in the context of their course?*
- **RQ3:** *What are the students' experiences with LLMs for text and computer code generation, and what do they expect or recommend?*

We employ a mixed methods approach using both a quantitative (QUAN) and qualitative (QUAL) approach to perform the analysis of the online survey data.

A. Sample and study instrument

The study is focused on higher education students, and it was conducted with the participation of students from Linnaeus University in Sweden and Ss. Cyril and Methodius University of Skopje in N. Macedonia. A total of 112 bachelor students out of the 300 invited students answered the survey. They belong to study programs within the computer science and information systems domains. The study started in March 2023 and took place over 10 weeks during the 2023 spring semester. The methodological framework is shown in Figure 1 and consists of two stages.

We initially use a survey to evaluate students' learning experiences and familiarity with LLMs, with a special emphasis on ChatGPT. This represents the first stage of the study, and the focus is on graphical data analysis. In addition, within this single study, the research also incorporates elements of a qualitative approach while analyzing the answers to the open-ended questions, which are part of the same survey. This constitutes the second stage of the study.

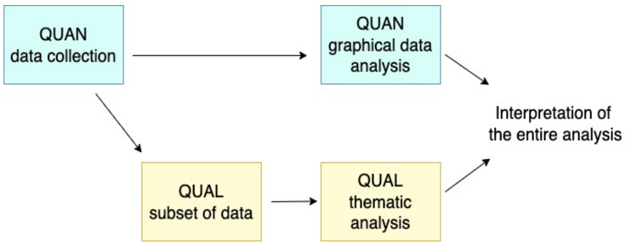


Fig. 1. Schematic representation of the method steps adopted in the study

Thematic content analysis was used in order to capture the emergent categories or themes from three open-ended questions. This involves using an inductive thematic method to find recurrent ideas across several sentences. There are six steps to this process: *familiarization with the data*, *creating initial codes*, *looking for themes*, *reviewing the themes*, *defining the themes*, and finally *naming the themes* [28]. Using the Delve® tool, the authors inductively coded the answers. In order to be ready for the next stages, the codes were compiled, merged, and categorized to reveal commonalities and trends. After reaching consensus on the generated themes and their definitions, we followed the guidelines laid forth by [31, 32], and constructed a narrative via individual and collaborative efforts. Six overarching themes emerged from the process as a whole, and they are discussed in detail in Section 4.

B. *Sampling technique and survey structure*

In the current study, the purposive homogeneous sample method was used, where the respondents are all members of one similar subgroup (computer and information science students) and are carefully selected with the expectation that each participant will provide distinct and rich information of value to the study [33]. The survey was distributed within courses and the university Slack server.

Before administering the survey, confidentiality and ethical considerations were conveyed to all participants via an information sheet that outlined the importance of maintaining anonymity. This also included that participation is voluntary and that the results will only be presented in aggregated form. The survey consists of 14 items (questions) and is composed of three parts. The first part contained questions about participants' demography, including study program and year of study, whereas the second part included questions related to students' attitude, familiarity, and awareness about ChatGPT as a learning tool. The third part included questions related to experiences and expectations (recommendations) from the usage of ChatGPT in educational settings. In this part, more useful and contextual feedback was obtained through the three open-ended questions that were part of the survey. The survey structure and its questions can be accessed through the following link: *https://tinyurl.com/365wfpmc*.

IV. Findings and Discussion

Based on the students' demographic data, results revealed that third year students were more represented in the study (43.7%), followed by first year students (19.6%), and the remaining participants are either second- or fourth-year students. All students are studying computer science and information systems at the undergraduate level, more specifically information systems and interaction design (29.5%), computer science (27.7%), software engineering and information systems (27.7%), computer engineering (6.3%), application of information technologies (5.4%), internet, networks and security (2.7%), and media technology (1%). The remaining sections present the results that respond to our three research questions.

Figure 2 (left) shows that 63% of students had used ChatGPT extensively or tried it once. The right graph in Figure 2 displays additional LLMs students are aware of. Besides ChatGPT, they know GitHub Copilot and Bing.

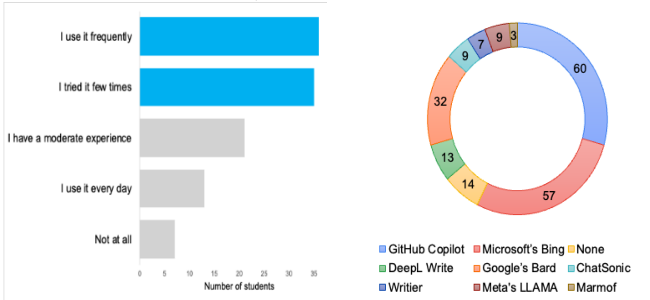


Fig. 2. (left) Students' experience with ChatGPT / (right) Familiarity with other known LLMs.

Student motivations for utilizing ChatGPT were used to answer RQ2. As shown in Figure 3 (left), the major motivation is to acquire answers to learning questions, although over half also use ChatGPT for coding assignments. Regarding learning tasks like writing essays (reports), as illustrated in Figure 3 (right), 70% of students, or 78 of them, utilize ChatGPT somewhat to extensively. For practical problem-solving, 67% of students prefer ChatGPT. These findings show that students routinely utilize ChatGPT in higher education, despite its novelty. Another study by Strzelecki [27] examined how higher education students utilize ChatGPT, but more research is needed on AI chatbots in education.

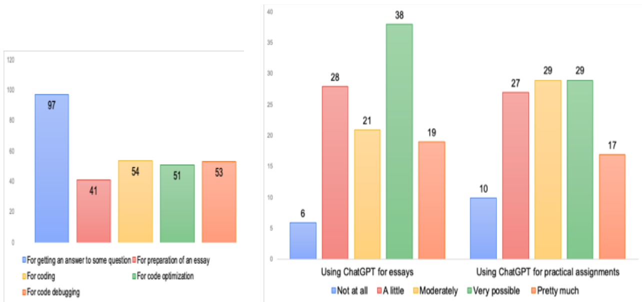


Fig. 3 (left). Motivation for using ChatGPT / (right) Using ChatGPT for essays and practical assignments.

Surprisingly, only 24 students (21%) would consider checking the result for plagiarism. Students, however, may find it challenging to discern between verified material and true knowledge due to large language models' capacity to produce text that looks like human.

When it comes to the students' attitudes toward the generated text and coding results via ChatGPT, their feedback shown in Figure 4, is quite mixed. In fact, for both categories of the generated result, they expressed their reservation before directly utilizing it in the course assignments. A vast majority (78%) think that any text generated by ChatGPT should be verified for its relevance before using it, by also considering introducing additional references to strengthen it further. In favour of paraphrasing and reading the output carefully before using it in the assignments were 41% and 34% of the respondents, respectively.

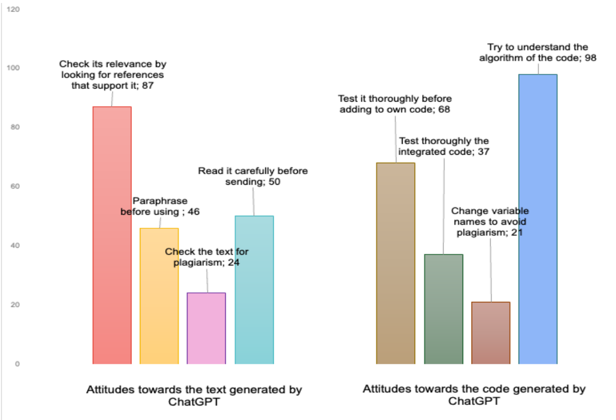


Fig. 4. Attitudes of students towards the results generated with ChatGPT.

This can drive students to trust material that is erroneous or deceptive without checking its veracity. Therefore, it is crucial to educate students on how to critically analyze material and to teach them research, verification, and corroboration techniques to mitigate these risks [29, 12]. Regarding the attitudes towards the computer code generated by ChatGPT, more than 87% of students would first attempt to understand the generated code before submitting it for grading. For reusing the code, 68 students (61%) would first test it thoroughly before the use, whereas a small percentage of them (33%) would test the integrated code. The body of knowledge is also confirming the enormous potential of LLMs such as ChatGPT for supporting programming modeling tasks, if a textual problem description of the domain to be modeled exists [30]. Next, we asked our students about their overall perception for utilizing ChatGPT as a learning tool, including also during the examination, and the results are quite opposite. As shown in Figure 5, the positive perceptions on using ChatGPT as a learning tool prevails among the majority of the respondents.

On the other hand, almost the same number of respondents (76%) would disagree with the idea of allowing ChatGPT to be used during exams, making it a potential threat to the integrity of the exams (proctored or online). In the current higher education settings, where especially online exams are becoming more prevalent, ChatGPT would pose high risks of cheating and academic misconduct [34, 35]. To ensure the validity and fairness of online exams for all students, it is essential for educators and institutions to be prepared for the risk of ChatGPT and other AI tools being used for cheating and to investigate solutions to them.

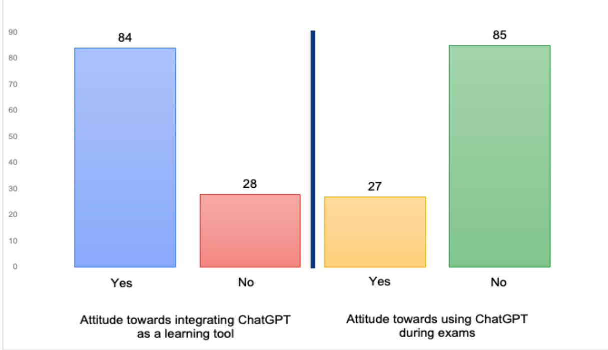


Fig. 5. Overall perceptions towards using ChatGPT for learning and during examination

The data gathered through open-ended questions (qualitative approach) is used to find answers to RQ3. As can be seen from Figure 6, the thematic analysis resulted in the identification of six themes, namely: *learning content creation*, *editing and refining*, *generating new code*, *biased outputs*, *reduced critical thinking*, and *academic integrity*. Regarding the creation of learning content, participants in the survey shared a variety of experiences using ChatGPT for course related text generation, with many finding it to be a useful tool for generating contextually pertinent content across multiple courses. Based on the empirical evidence, students highly valued ChatGPT's ability to understand contextual nuances, produce diverse answers, and serve as a catalyst for creative writing. Additionally, the utility of ChatGPT extends to summarizing academic chapters, generating illustrative examples, and elucidating complex ideas, affirming its role as an effective educational aid. These results align with existing scholarly works [36, 37].

Fig. 6. Identified themes from the open-ended questions.

Editing and refining was the second theme identified. Respondents here emphasized the need to develop their own writing skills and seek guidance from their professors and academic advisors when working on essays. They can use ChatGPT as a complementary tool but should not rely solely on it to produce good essays [38]. Almost always editing and refining the generated text is performed before potential use.

Next, two additional themes related to generating new code and biased outputs were identified. Numerous respondents to the survey reported diverse ChatGPT code generation experiences. For some, it was useful for generating basic code fragments and debugging activities. Additionally, students expressed how ChatGPT can help them comprehend code, sparing them time compared to seeking answers online.

Some users reported utilizing ChatGPT for code optimization, scaffolding, refactoring, and library recommendations [39].

Nonetheless, respondents also identified shortcomings in ChatGPT's code generation potential. Artificial intelligence-generated code might not be optimal, could be biased and have errors, and might not follow best practices [40]. Some participants reported that the efficacy of ChatGPT varied depending on the programming language or framework, with improved results for more popular programming languages. Others mentioned that ChatGPT may produce irrelevant or inaccurate code, necessitating users to evaluate and modify the output prior to implementation [41]. Despite these constraints, many respondents found ChatGPT useful as a supplement for code generation and comprehension, provided they evaluated the generated code critically and learned from it.

Respondents' perspectives on incorporating ChatGPT differ, with some highlighting the significance of responsible usage, critical thinking, and knowing the technology's limits. While there are concerns about the prospect of abuse and bad effects on learning, many respondents agree that if used appropriately, ChatGPT may be a helpful tool, and that incorporating it into education is unavoidable as technology advances. While ChatGPT may provide logical replies, it may also fail to comprehend complicated situations or nuances [42]. Students should be aware of this constraint and use critical thinking to fill in gaps, verify material, and accurately evaluate replies. An excessive reliance on ChatGPT might prevent the development of autonomous critical thinking abilities [43]. Therefore, students should utilize it as a tool rather than a solitary source of knowledge, actively interacting with other resources and seeking other views to develop their own analytical skills.

With regards to *academic integrity*, which was the last theme identified, the respondents admitted that ChatGPT may lead to academic dishonesty and cheating if not properly monitored and controlled. It may be easy to confuse text produced by humans and machines while using ChatGPT, which can be exploited to aid cheating. Universities must make efforts to guarantee that these tools are utilized in an ethical and responsible manner as well as carefully weigh the benefits and hazards of doing so. This may entail creating guidelines and regulations for their application, train students and faculty, support them, and use a number of tools to identify and prevent academic dishonesty [44].

V. Conclusion and Recommendations

For ages, new educational technologies have contributed to better and more effective education. They have gradually transformed the traditional teaching and evaluation methods. The speed of introduction of the latest technologies is incomparable with the previous ones, and at this moment, LLMs are at their peak, while their possibilities fascinate students as well as their professors. This mutual interest in using them for various goals was the main motivation to propose a strategy for integrating LLMs into education.

Aware of the daunting dimension of the challenges that AI and LLMs bring with them, we first investigated them in detail. In addition to the general problems discussed in Section 2, the authors of this paper highlight challenges that are directly related to the educational dimension of LLMs. They embrace: the reduced desire for independent research and critical thinking due to instant information availability; the difficulties in distinguishing credible from fake information, primarily as a result of the lack of transparency of the sources used by LLMs; the reduced opportunities to develop research skills, creativity and logical thinking; and the excessive reliance on generated code without understanding its functionality and integration, which hinders the development of skills in programming tasks.

In order to propose an innovative strategy that is acceptable to students, initially we tried to understand their perspective based on face-to-face interviews and through a survey that was processed quantitatively and qualitatively. Based on this analysis, we propose the following recommendations:

1. LLMs should not be used in exams, at least not without a prior training within a special dedicated compulsory course intended for all students, in order to reduce the risk of discrimination against students who are not skilled enough to use them.

2. LLMs should be used for the creation of essay assignments, enabling three approaches:

   a) Creation of essays without the use of LLMs, emphasizing the research questions, the references through which the answers to these research questions are obtained and the new facts based on the retrieved references.
   b) Completely LLMs-based review essays, where the questions posed to LLMs, the answers LLMs generated and the references proving their credibility are explicitly presented.
   c) Hybrid, where students combine the first two approaches in the proportions that suits them best.

In all three approaches, the author’s contribution and critical attitude must me emphasized throughout the assignments.

3. LLMs should be used for programming assignments for various purposes:

   a) For creation of code fragments, highlighting which parts of the code are LLMs generated, why they were not able to code them individually, how is their quality evaluated and how were they integrated into own code.
   b) For debugging activities, comparing their bug code and the differences LLMs made to debug it.
   c) For code optimization, presenting the performance-critical sections of original code, its complexity and efficiency and the LLMs generated optimized code.
   d) For code refactoring, underlining the design, structure and implementation deficiencies of the legacy software and comparing the existing code with the refactored one.

Like most technology, the challenge is our sentiments, experiences, and responses to it. LLMs like ChatGPT sparked discussion, excitement, and concern in higher education. Many academics appreciate AI writing tools' promise, while those accustomed to doing things in specific ways struggle to adapt to their rapid changes. We intend to use the recommended method in our courses during the next academic year, believing that it will improve the quality of courses and the knowledge will be improved.

References

[1] B. Dennis, "From pencils to pixels: The stages of literacy technologies", Writing about writing: A college reader, 1999, pp. 690-708.

[2] Hackeducation, http://hackeducation.com/2015/03/12/calculators, last accessed 2023/06/15.

[3] A. Ralston, "Let's abolish pencil-and-paper arithmetic", Journal of Computers in Mathematics and Science Teaching, vol. 18, no. 2, 1999, pp. 173-194.

[4] D. M. Roberts, "The impact of electronic calculators on educational performance", Review of Educational Research, 50(1), 1980, pp. 71-98.

[5] E. L. Bunker, "The history of distance education through the eyes of the International Council for Distance Education", Handbook of distance education, 2003, pp. 49-66.

[6] C. C. Schifter, "Faculty participation in asynchronous learning networks: A case study of motivating and inhibiting factors", Journal of Asynchronous Learning Networks, 4(1), pp. 15-22, 2000.

[7] M. Etherington, "E-learning pedagogy in the primary school classroom: the McDonaldization of education", Australian Journal of Teacher Education, vol. 33, issue 5, pp. 29-54, 2008.

[8] D. Vlachopoulos, "COVID-19: Threat or opportunity for online education?", Higher Learning Research Communication, 10(1), pp. 16–19, 2020.

[9] K. Zdravkova, F. Dalipi, V. Krasniqi, "Remote Education Trajectories for Learners with Special Needs during the Covid-19 Outbreak: An Accessibility Analysis of the Learning Platforms", International Journal: Emerging Technologies in Learning, 17(21), pp. 89-122, 2022.

[10] B. Ferster, "Teaching machines: Learning from the intersection of education and technology", JHU Press, 2014.

[11] ChatGPT, https://openai.com/blog/chatgpt, last accessed 2023/06/12.

[12] E. Kasneci, K. Seßler, S. Küchemann, S. et al.," ChatGPT for good? On opportunities and challenges of large language models for education", Learning and Individual Differences, vol. 103, 102274, 2023.

[13] UN News homepage, https://news.un.org/en/story/2021/09/1099972, last accessed 2023/06/11.

[14] S. Flynn, "WIPO Conversation on Intellectual Property (IP) and Artificial Intelligence (AI)", The World Intellectual Property Organization, 2020.

[15] European Commission IP Helpdesk, https://intellectual-property-helpdesk.ec.europa.eu/news-events/news/intellectual-property-chatgpt-2023-02-20_en, last accessed 2023/06/09.

[16] UN Department of Economic and Social Affair, https://www.un.org/en/desa/will-robots-and-ai-cause-mass-unemployment-not-necessarily-they-do-bring-other, last accessed 2023/06/13.

[17] J. A. Goldstein, G. Sastry, M. Musser, R. DiResta, M. Gentzel, K. Sedova, "Generative Language Models and Automated Influence Operations: Emerging Threats and Potential Mitigations", 2023, https://arxiv.org/abs/2301.04246.

[18] OECD Forum, https://www.oecd-forum.org/posts/the-promises-pitfalls-and-potential-of-global-technology-governance, last accessed 2023/09/25.

[19] Health Sector Cybersecurity Coordination Center, https://www.hhs.gov/sites/default/files/ai-for-malware-development-analyst-note.pdf, last accessed 2023/09/25.

[20] UNESCO, Ethics of Artificial Intelligence, https://www.unesco.org/en/artificial-intelligence/recommendation-ethics, last accessed 2023/09/25.

[21] The decision lab, https://thedecisionlab.com/biases/google-effect, last accessed 2023/09/25.

[22] Uni. of Wisconsin - Madison, https://dept.writing.wisc.edu/wac/why-should-i-use-writing-assignments-in-my-teaching/, last accessed 2023/09/25.

[23] GitHub, https://github.com/google, last accessed 2023/09/25.

[24] BestColleges, https://www.bestcolleges.com/news/will-colleges-ban-chatgpt/, last accessed 2023/09/25.

[25] IB, https://www.ibo.org/news/news-about-the-ib/statement-from-the-ib-about-chatgpt-and-artificial-intelligence-in-assessment-and-education/, last accessed 2023/09/25.

[26] Springer, https://www.springer.com/journal/10584/updates/24013930, last accessed 2023/09/25.

[27] A. Strzelecki, "To use or not to use ChatGPT in higher education? A study of students' acceptance and use of technology", Interactive Learning Environments, pp. 1-14, 2023.

[28] V. Braun, and V. Clarke," Using thematic analysis in psychology. Qualitative research in psychology, 3(2), pp. 77-101, 2006.

[29] E. Bauer, M. Greisel, I. Kuznetsov, M. Berndt, I. Kollar, M. Dresel, M. & F. Fischer, "Using natural language processing to support peer‐feedback in the age of artificial intelligence: A cross‐disciplinary framework and a research agenda", British Journal of Educational Technology, 2023.

[30] H. G. Fill, P. Fettke, J. Köpke, "Conceptual Modeling and Large Language Models: Impressions from First Experiments With ChatGPT", Enterprise Modelling and Information Systems Architectures (EMISAJ), 18, pp. 1-15, 2023.

[31] Y. Lincoln, and E. Guba, "Naturalistic Inquiry", California: Sage Publications, 1985.

[32] J.W. Creswell, and J.D. Creswell, "Research design: qualitative, quantitative, and mixed methods approaches", Fifth edition, Los Angeles: Sage, 2018.

[33] J.W. Creswell, and D.L. Miller," Determining Validity in Qualitative Inquiry, Theory Into Practice", 39:3, pp. 124-130, 2000.

[34] T. Susnjak, "ChatGPT: The End of Online Exam Integrity? arXiv preprint arXiv:2212.09292, 2022.

[35] C. K. Lo," What is the impact of ChatGPT on education? A rapid review of the literature", Education Sciences, vol. 13, no. 4, 410, 2023.

[36] C.W. Okonkwo, & A. Ade-Ibijola, "Chatbots applications in education: A systematic review", Computers and Education: Artificial Intelligence, 2, 100033, 2021.

[37] N. Sandu, & E. Gide, "Adoption of AI-Chatbots to enhance student learning experience in higher education in India", In 2019 18th IEEE International Conference on Information Technology Based Higher Education and Training (ITHET), pp. 1-5, 2019.

[38] X. Zhai, "Chatgpt for next generation science learning. XRDS: Crossroads", The ACM Magazine for Students, 29(3), pp. 42-46, 2023.

[39] S.I. Ross, F. Martinez, S. Houde, M. Muller, J.D. Weisz, "The programmer's assistant: Conversational interaction with a large language model for software development", In Proceedings of the 28th International Conference on Intelligent User Interfaces, pp. 491-514, 2023.

[40] M. Kazemitabaar, J. Chow, C.K.T. Ma, B.J. Ericson, D. Weintrop & T. Grossman, "Studying the effect of AI Code Generators on Supporting Novice Learners in Introductory Programming", In Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems, pp. 1-23, 2023.

[41] E. Ferrara, "Should ChatGPT be biased? Challenges and risks of bias in large language models", arXiv preprint arXiv:2304.03738, 2023.

[42] J. Deng, & Y. Lin, "The Benefits and Challenges of ChatGPT: An Overview. Frontiers in Computing and Intelligent Systems", 2(2), pp. 81-83, 2022.

[43] M. Farrokhnia, S.K. Banihashem, O. Noroozi, & A. Wals, "SWOT analysis of ChatGPT: Implications for educational practice and research", Innovations in Education and Teaching International, pp. 1-15, 2023.

[44] D.R. Cotton, P.A. Cotton, & J.R. Shipway, "Chatting and cheating: Ensuring academic integrity in the era of ChatGPT", Innovations in Education and Teaching International, pp. 1-12, 2023.

DEVELOPMENT OF COMPUTATIONAL THINKING THROUGH THE MICRO:BIT: AN EXPERIENCE IN THE ICT SUBJECT

Desenvolvimento do Pensamento Computacional através do micro:bit: uma experiência na disciplina de TIC

Pedro Brandão
Instituto de Educação
Universidade de Lisboa
Lisboa, Portugal
pedro.brandao@edu.ulisboa.pt

Neuza Pedro
Instituto de Educação
Universidade de Lisboa
Lisboa, Portugal
nspedro@ie.ulisboa.pt

Alexandra Carvalho
Departamento de Informática
Agrupamento de Escolas de Alvalade
Lisboa, Portugal
alexandra.carvalho@aealvalade.edu.pt

***Abstract*— This article describes a Supervised Teaching Practice, the internship component of the Master's degree in Teaching Informatics of the University of Lisbon. Focusing on a 9th grade class, this intervention took place in the Information and Communication Technologies curricular subject. Since the intervened school adopted a STEM (Science, Technology, Engineering and Mathematics) approach, part of the contents of the ICT subject were taught through the development of projects in articulation with the other subjects. The aim was to develop computational thinking skills in students through the use of the micro:bit board, which can be programmed through the MakeCode platform. Students were challenged to create a game called 'Reaction time', through collaborative group work. The results showed that the use of visual block programming platforms motivate students to learn programming and that differences were detected in students' motivation for learning programming considering their attendance level.**

Keywords — Computational Thinking, Information and Communication Technologies, MakeCode, micro:bit, STEM

I. INTRODUÇÃO

O presente trabalho centra-se a numa atividade educativa realizada durante a Prática de Ensino Supervisionada (PES) do Mestrado em Ensino da Informática da Universidade de Lisboa no ano letivo 22/23. A PES decorreu na disciplina de Tecnologias de Informação e Comunicação (TIC) no 3º ciclo do Ensino Básico na Escola Secundária Padre António Vieira (ESPAV) em Lisboa. No ano letivo em causa, a escola adotou uma abordagem STEM na lecionação de diferentes disciplinas, pelo que o projeto realizado e que seguidamente se descreve e envolveu a colaboração dos professores de TIC Ciências da Natureza, Matemática e Físico-Química. O projeto em causa pretendeu levar os alunos de uma turma do 9º ano a desenvolver um jogo utilizando a placa programável micro:bit, programada na plataforma de programação por blocos MakeCode, com o intuito de desenvolver nestes competências do Pensamento Computacional (PC).

II. PENSAMENTO COMPUTACIONAL

O PC é um tema atual, visto como fundamental na obtenção de competências para o século XXI. Para Jeannette Wing, talvez a mais importante impulsionadora da reflexão sobre este conceito, o PC "representa um conjunto de competências e atitudes aplicáveis universalmente que toda a gente, não só os cientistas da computação, deviam estar desejosos por aprender e utilizar" (Wing, 2006, p. 1). O PC está a influenciar cada vez mais áreas do saber dado que possui muitas características que são benéficas ou até necessárias para a aquisição de conhecimentos em diferentes disciplinas (Wing, 2006).

Para a *International Society for Technology in Education* (ISTE) e para a *Computer Science Teachers Association* (CSTA), (ISTE/CSTA, 2011), o PC é um processo de resolução de problemas que envolve as seguintes características:

- Formulação de problemas de uma forma que nos permita utilizar um computador e outras ferramentas para ajudar a resolvê-los;
- Organização e análise lógica de dados;
- Representação de dados através de abstrações, tais como modelos e simulações;
- Automatização de soluções através do pensamento algorítmico;
- Identificação, análise e implementação de possíveis soluções com o objetivo de alcançar a combinação mais eficiente e eficaz de passos e recursos para resolução do problema em causa;
- Generalização e transferência do processo de resolução do problemas aplicado para uma grande variedade de outros problemas ou contextos.

Com base nas diversas variações encontradas para a definição de PC, podemos identificar alguns dos seus pilares: identificação e decomposição de problemas, que consiste na divisão de problemas em partes menores, facilitando a sua resolução; a abstração, que propõe a filtragem dos elementos desnecessários à resolução de um problema, dando foco aos elementos fundamentais; o reconhecimento de padrões, que permite identificar padrões que podem ser generalizados; e o desenho de algoritmos, que se liga ao desenvolvimento e implementação passo-a-passo de uma solução para um dado problema.

III. STEM

A abordagem STEM tem vindo a ser cada vez mais utilizada no ensino, pois permite uma abordagem interdisciplinar e colaborativa que incentiva transdisciplinaridade, a criatividade e o pensamento crítico dos alunos (Felder, 2019). Esta abordagem procura dar um significado mais real e prático às aprendizagens escolares, interligando os conhecimentos adquiridos em várias disciplinas científicas e aplicando-os a contextos e situações específicas.

Na escola onde decorreu a PES aqui descrita, a disciplina de TIC foi, no ano letivo em causa, lecionada em articulação com as disciplinas de Ciências Naturais e Físico-Química. Esta articulação foi posta em prática através do desenvolvimento de projetos interdisciplinares envolvendo

IV. MICRO:BIT & MAKECODE

O micro:bit (Fig. 1) é uma placa programável de pequenas dimensões e com um preço acessível, desenvolvida em 2015 no âmbito da iniciativa BBC "*Make it Digital*", com o objetivo de "inspirar os jovens a serem criativos com as tecnologias digitais e a desenvolverem competências nucleares em ciências, tecnologia e engenharia" (Sentance, Waite, Hodges, MacLeod, & Yeomans, 2017, p. 1). A primeira versão do micro:bit foi distribuída gratuitamente para cerca de 1 milhão de estudantes do ensino básico no Reino Unido. Desde então,

o micro:bit tem sido utilizado em escolas e projetos por todo

o mundo e o seu impacto no ensino e no desenvolvimento do PC tem sido positivamente documentado.

Vários estudos de (Chang, Chen, & Chen, 2019; Kirschner, Paas, & Kirschner, 2016) têm permitido verificar que a utilização da micro:bit no ensino de programação e pensamento computacional melhora a motivação e o desempenho dos estudantes, ao mesmo tempo que contribui positivamente para a compreensão de conceitos relevantes para a programação, aumentando ainda os níveis de interesse dos alunos por esses assuntos. Outro estudo realizado (Hwang, Chiang, & Chiang, 2018) mostra que a utilização da placa micro:bit no ensino de programação pode melhorar a capacidade dos estudantes de resolver problemas e de pensar computacionalmente.

Existem várias plataformas que permitem programar a placa micro:bit. É possível utilizar editores de blocos, como o Scratch 3 ou o Thinkercad, ou então usar linguagens de programação como Python, C++ ou JavaScript. No entanto, a plataforma de referência desta placa é o simulador Microsoft MakeCode (https://makecode.microbit.org) que permite programar o micro:bit utilizando blocos semelhantes aos utilizados em outros ambientes de programação por blocos

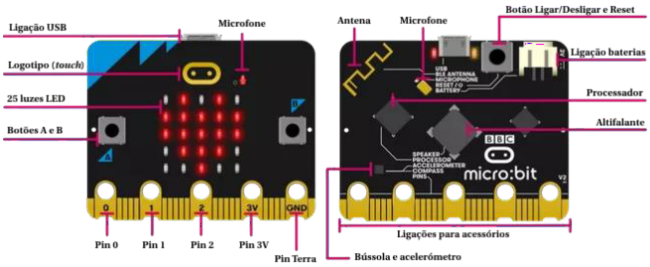


Fig. 1. Componentes da placa micro:bit (retirada e adaptada de https://microbit.org/pt-pt/get-started/user-guide/overview/)

conteúdos programáticos das diferentes disciplinas envolvidas.

(ex. Scratch), ao mesmo tempo que permite programar em Python e em JavaScript. Esta plataforma (Fig. 2) funciona igualmente como um simulador permitindo, como tal, a testagem de programas, fornecendo feedback imediato, sem ser necessário o envio dos programas para a placa.

A interface da plataforma MakeCode é intuitiva, baseando-se no sistema *drag-and-drop*, o que a torna fácil de utilizar até mesmo por quem nunca programou anteriormente.

A plataforma MakeCode permite ainda o trabalho colaborativo de diferentes pessoas num mesmo projeto e, sendo desenvolvida pela Microsoft, integra-se facilmente com outras ferramentas, como por exemplo o Microsoft Teams, permitindo a fácil partilha de projetos entre alunos e professores.

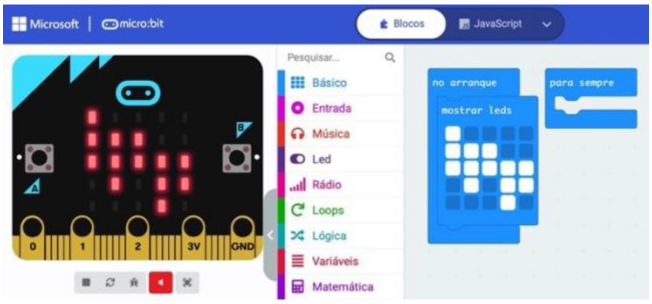


Fig. 2. Interface do MakeCode (retirada de: https://makecode.microbit.org)

V. PROGRAMAÇÃO POR BLOCOS

A programação por blocos é um método de programação visual que permite aos utilizadores criar programas sem escrever código de programação tradicional (Costa, 2020). O conceito foi criado na década de 1960 por Seymour Papert com o objetivo de tornar a programação acessível a crianças (Papert, 1980). O conceito de programação por blocos não é novo e tem vindo a ser apresentado a crianças cada vez mais jovens com o objetivo de estimular a aprendizagem da matemática, desenvolver o raciocínio lógico, a resolução de problemas, competências de PC, enquanto promove o trabalho cooperativo e a criatividade.

Kelleher e Pausch indicam que uma das vantagens da programação por blocos é a de facilitar a aprendizagem inicial da programação, dado que os utilizadores não precisam ter conhecimentos avançados de programação para criar programas (Kelleher & Pausch, 2005), na medida em que se apresenta como uma forma visualmente atrativa e eficaz de introduzir as crianças ao mundo da programação que, à primeira vista, é por estas entendido como complicado.

VI. INTERVENÇÃO PEDAGÓGICA

A turma intervencionada, do 9º ano do 3º ciclo do ensino básico, era composta por 21 alunos com idades compreendidas entre os 13 e os 16 anos, com uma média etária de 14,2 anos. Dos 21 alunos, 8 eram rapazes e 13 raparigas. Quanto às nacionalidades, 20 eram de nacionalidade portuguesa e 1 aluno era de nacionalidade brasileira.

A intervenção pedagógica decorreu durante o segundo semestre, num processo que envolveu diversas fases: a observação de aulas, a definição de temas e objetivos de aprendizagem a trabalhar, o planeamento da intervenção, através da construção de um cenário de aprendizagem, a seleção das metodologias e estratégias pedagógicas a adotar, a criação das atividades e dos respetivos recursos de apoio às aprendizagens a disponibilizar, bem como a definição dos métodos e tipos de avaliação a estabelecer.

A intervenção pedagógica teve a duração de 500 minutos, ou seja, 10 aulas de 50 minutos. Dado que, a turma intervencionada, tinha blocos de aulas de 100 minutos numa frequência quinzenal, foram intervencionadas 5 aulas de 100 minutos, ao longo de aproximadamente um mês e meio.

Quanto aos 500 minutos de intervenção, 300 desses minutos (3 blocos de 100 minutos) foram dedicados à utilização da placa micro:bit no desenvolvimento do PC, foco principal deste artigo. Esta limitação aconteceu devido à sobreposição do tempo previsto para o processo intervenção com a véspera do “Dia D” que decorreu na ESPAV. Sendo assim, os 200 minutos restantes foram dedicados à planificação e elaboração de materiais de divulgação de trabalhos e iniciativas realizados pelos alunos do AEA que foram apresentados por estes no “Dia D”.

VII. Jogo “Tempo de Reação”

A proposta de atividade apresentada foi o desenvolvimento de um jogo, designado de “Tempo de Reação” como um projeto a ser desenvolvido, em grupo, pelos alunos.

Este projeto consistia na criação de um jogo para 2 jogadores que, de um modo básico, registaria quem tinha o melhor tempo de reação (Fig.3). Os jogadores deveriam ser chamados a reagir a um estímulo visual do micro:bit e, tendo ambos a mão no botão de alumínio central, teriam que colocar a outra mão no botão de alumínio do seu lado, de forma a fecharem o circuito mais rapidamente que o adversário. O botão “Start” iniciaria cada iteração do jogo.

Tendo este jogo como base, surgiu a ideia de o utilizar como forma de decidir quem responde primeiro a questões relacionadas com os sistemas do corpo humano, introduzindo-se assim a matéria da disciplina de Ciências Naturais, sendo que a montagem física e funcionamento básico do jogo inclui a mobilização de conhecimentos de circuitos elétricos abordados na disciplina de Físico-Química (Fig.4).

A versão base do jogo permitia várias fases de aprimoramento, sendo que, em cada fase eram adicionadas novas funcionalidades ao jogo. Este contínuo aprimoramento pretendia estimular o desenvolvimento de competências de PC nos alunos dado que, a adição de uma nova funcionalidade (ex. registar e mostrar pontuações; terminar o jogo quando um jogador atinge 5 pontos) trazia inerente o surgir de novos problemas que os alunos deveriam identificar e resolver. Os blocos necessários ao desenvolvimento do jogo incluíam as noções de *input* e *output*, instruções sequenciais, ciclos,

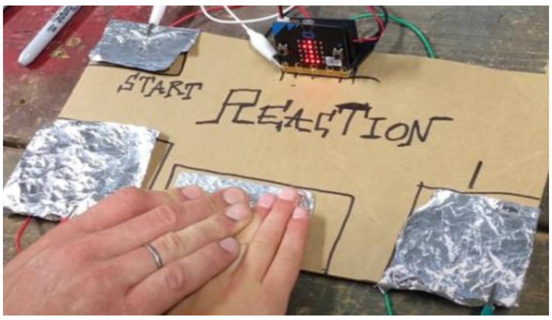


Fig. 3. "Reaction Game" (fonte: https://www.youtube.com/watch?v=DgJ-S0q0EMs&t=415s)

Fig. 4. Imagem ilustrativa do jogo a desenvolver pelos alunos

estruturas condicionais e variáveis, incluindo ainda o uso de dados booleanos, bem como a análise e avaliação de resultados e depuração através de *debug*.

VIII. Problema de Investigação

Face ao cenário proposto, foram então definidas as seguintes questões de investigação: A utilização de plataformas de programação visual por blocos motiva dos alunos para a aprendizagem de programação? (Q1). Em consequência pretendeu-se ainda testar se existiam diferenças associadas à motivação dos alunos para a aprendizagem de programação advindas da assiduidade dos alunos e do respetivo contacto com plataformas de programação visual (Q2).

Para estas questões assumiram-se, respetivamente, as seguintes hipóteses:

H1) A interação com plataformas de programação visual revela-se promotora de motivação dos alunos para a aprendizagem da programação.

H2) Existem diferenças associadas à motivação dos alunos para a aprendizagem de programação advindas da assiduidade dos mesmos, sendo que os alunos que apresentam maior assiduidade serão igualmente aqueles que apresentam maior motivação para a aprendizagem da programação.

Para a dimensão de investigação deste projeto utilizou-se o método quantitativo e um Design Pré-experimental de caso-único, sem qualquer aleatorização no processo de seleção dos participantes. O processo de recolha de dados realizou-se através da aplicação de um “pós-teste”, desenvolvido com base em escalas de motivação existentes, estruturando-se uma escala de motivação específica para a aprendizagem de programação. A mesma foi disponibilizada *online*, utilizando-se a plataforma de criação de formulários *online*, Google Forms. Entende-se que o (pós-)teste é uma ferramenta valiosa para medir o impacto de uma dada intervenção, permitindo aos investigadores avaliar os efeitos atingidos bem como identificar quaisquer problemas ou limitações (Coutinho, 2011).

A escala de motivação desenvolvida para este estudo era constituída por 4 questões. As duas primeiras questões, de escolha múltipla, averiguavam o género e a idade dos participantes. A terceira questão, igualmente de escolha múltipla, averiguava a assiduidade dos alunos nas aulas relativas à utilização do micro:bit e MakeCode, durante as quais se desenvolveu do jogo "Tempo de Reação". Este parâmetro foi introduzido de forma a ser possível analisar também a relação da motivação face à assiduidade dos alunos. A quarta e última questão era composta por 21 afirmações, estas sim constitutivas da escala criada (Fig. 5). As opções de resposta assumiam 5 variações que se situam entre "Concordo totalmente" (categorizada com 1 ponto) e "Discordo totalmente" (categorizada com 5 pontos), permitindo-se assim a possibilidade de uma resposta neutra.

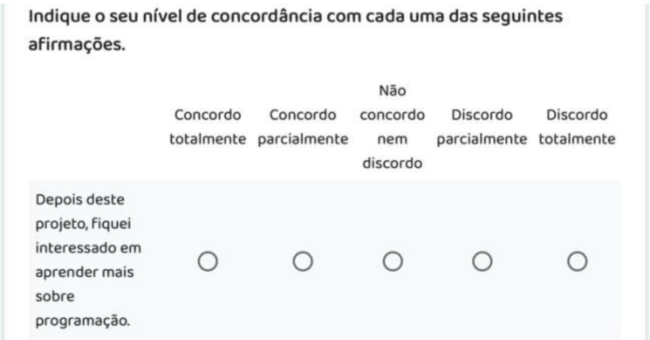


Fig. 5. Excerto da questão 4 - escala de motivação

IX. RESULTADOS

A plataforma Google Forms gera automaticamente gráficos relativos às respostas as quais são seguidamente apresentadas. Da questão relativa à assiduidade dos alunos, resultou o seguinte gráfico (Fig. 6) que mostra que 70% dos alunos estiveram presentes em todas as aulas relativas ao desenvolvimento do jogo "Tempo de Reação", utilizando o micro:bit programado através da plataforma MakeCode.

O ficheiro exportado do Google Forms serviu como base de dados para a análise realizada no SPSS. Desta forma, foram analisadas as frequências de resposta a cada um dos itens constituintes da questão 4, sendo para estes calculados os valores relativos a médias e desvios-padrão. Foram também realizados os testes de Levene (que assegurou a possibilidade de utilização de testes paramétricos) e o Teste- t Student.

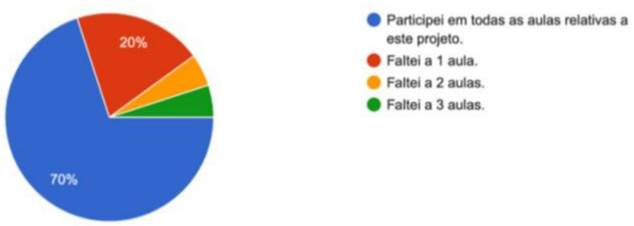


Fig. 6. Respostas dos alunos em relação à assiduidade nas aulas sobre micro:bit e MakeCode

Analisando os valores registados, observa-se que em todos os itens apresentados os mesmos tenderam a situar-se predominantemente entre os valores 3 e 4 (Média total: 3.661; Desvio-Padrão total: .069), sendo estes valores positivos e representativos de concordância com as afirmações sugeridas. Com base nestes resultados, pode afirmar-se que a utilização da plataforma MakeCode na programação do micro:bit contribui positivamente para a motivação dos alunos para a aprendizagem de programação, revelando-se esta elevada no final do projeto desenvolvido.

No que concerne à assiduidade, foram considerados dois grupos de alunos: os que participaram em todas as aulas sobre micro:bit e MakeCode (grupo 1) e os que faltaram a uma ou mais aulas (grupo 2).

TABELA 1. COMPARAÇÃO ENTRE OS GRUPOS 1 E 2

	N	Média	Desvio-Padrão	*t*	*df*	*p-value*
Grupo 1	14	4,014	,473	5,623	18	,000
Grupo 2	6	2,841	,277			

Analisando os resultados, é seguro afirmar-se que os alunos que frequentaram todas as aulas relativas à utilização destas plataformas apresentam níveis de motivação para a aprendizagem da programação mais elevados do que os alunos que faltaram a uma ou mais aulas. De acordo com o Teste-T Student, encontrou-se um valor de *p* menor que a probabilidade de erro (alpha= 0,05), logo as diferenças encontradas revelaram ser estatisticamente significativas.

X. CONCLUSÕES

O PC é amplamente considerado uma das competências importantes para o século XXI dada a abrangência da sua utilização. A inclusão de projetos de programação com artefactos digitais programáveis no ensino básico é, sem dúvida, uma forma eficaz de desenvolvimento de competências de PC. Deste trabalho pode concluir-se que a placa micro:bit, programada através da plataforma MakeCode, é uma excelente ferramenta para a realização de projetos, afetando positivamente a motivação dos alunos para a aprendizagem da programação, desenvolvendo ao mesmo tempo competências de PC.

REFERENCES

C. H., Chang, C. C., Chen, and Y. Y. Chen, (2019). The effect of using micro:bit on the learning of programming and computational thinking: A systematic review. *Journal of Educational Technology Development and Exchange*, vol. 12, number 1, pp. 1-12.

L. Costa, (2020). Desvantagens e vantagens da programação por blocos. *Revista Brasileira de Tecnologia da Informação*, vol. 2, number 2, pp. 1-6.

C. P. Coutinho (2011). *Metodologia de investigação em Ciências Sociais e Humanas, teoria e prática*. Edições Almedina.

R. M. Felder, (2019). STEM education: A perspective from engineering. *Journal of STEM Education,* vol. 20, number 2, pp. 1-7.

G. J., Hwang, Y. H., Chiang, and H. Y. Chiang. (2018). The effects of the Micro:bit on enhancing students' problem- solving abilities and computational thinking. *International Journal of Emerging Technologies in Learning (iJET*), vol. 13, number 5, pp. 31-42.

C. Kelleher and R.Pausch, (2005). *Lowering the barriers to programming: A taxonomy of programming environments and languages for novice programmers*. ACM Inroads, vol. 6, number 1, pp. 28-36.

P. A. Kirschner, F. Paas, and P. A. Kirschner. (2016). Computational thinking: *A new educational challenge. Educational Research Review*, vol. 16, pp. 62-71.

S. Papert (1980). *Mindstorms: Children, computers, and powerful ideas*. Basic books.

S. Sentance, J. Waite, S. Hodges, E. MacLeod, L. and Yeomans, (2017). *"Creating Cool Stuff."* Proceedings of the 2017 ACM SIGCSE Technical Symposium on Computer Science Education. https://doi.org/10.1145/3017680.3017749

J. M. Wing, (2006). Computational thinking. *Communications of the ACM,* vol. 49, number 3, pp.33. https://doi.org/10.1145/1118178.1118215

Aprender enseñando: creación de tutoriales con TutoApp en el ámbito de formación profesional

Sonia Ruiz-Olmedilla
Departamento de Informática y Estadística
Universidad Rey Juan Carlos
Móstoles, Madrid.
sonia.ruizolmedilla@educa.madrid.org

Isaac Lozano-Osorio
Departamento de Informática y Estadística
Universidad Rey Juan Carlos
Móstoles, Madrid.
0000-0002-2608-8464

Maximiliano Paredes-Velasco
Departamento de Informática y Estadística
Universidad Rey Juan Carlos
Móstoles, Madrid.
0000-0002-4555-3771

***Resumen*— El auge de las metodologías activas en educación y su importancia para atender a la diversidad presente en las aulas, se plantea como una oportunidad para realizar una intervención en la etapa de Formación Profesional introduciendo la metodología activa aprender enseñando, utilizando tecnología móvil a través de una aplicación Android, llamada TutoApp. Con esta aplicación los estudiantes crean tutoriales y breves cuestionarios relacionados con los contenidos a trabajar, de manera que este material facilite el aprendizaje tanto a sus creadores como al resto de compañeros. En la intervención descrita se valoran las emociones experimentadas por los estudiantes antes y después de la experiencia junto al rendimiento académico. La experiencia apunta a un mayor rendimiento en el aprendizaje y el dominio de los contenidos trabajados de los alumnos que usaron la herramienta de TutoApp respecto a los que no lo usaron. Sin embargo, no se encontró que el uso de la herramienta mejorase significativamente el estado emocional de los estudiantes.**

Palabras clave— Formación profesional, metodologías activas, aprender enseñando, aprendizaje móvil y emociones del estudiante.

I. Introducción

La Formación Profesional (FP) se caracteriza por proporcionar a los estudiantes las habilidades y conocimientos necesarios para desarrollarse en un campo profesional específico. No obstante, aunque desempeña un papel crucial en la preparación de los estudiantes para el mundo laboral, se observa que muchos estudiantes afrontan una serie de dificultades que pueden obstaculizar su aprendizaje y rendimiento académico [1]. Aunque el temario complicado y la desmotivación son problemas reconocidos [1], existen otros desafíos que enfrentan y afectan a los estudiantes de Formación Profesional: la falta de recursos didácticos adecuados, la ausencia de una orientación vocacional y la brecha entre la teoría y la práctica son factores que también influyen en los bajos rendimientos académicos, y que en muchos casos han sido agravados por la pandemia COVID-19 [2, 3].

De acuerdo con Duran [4], la introducción sistemática de prácticas donde los estudiantes aprenden enseñando a sus compañeros, no solo complementa las prácticas y la manera de enseñar del docente, también puede suponer una ayuda pedagógica en aulas con ratios elevadas. Asimismo, permite enriquecer la calidad educativa del alumnado, apostando por interacciones bidireccionales entre estudiantes debidamente planificadas, donde aprenden recíprocamente, unos de otros y viceversa, al tiempo que mejoran sus habilidades sociales.

Así pues, esta investigación, pretende hacer frente a algunos problemas identificados y relacionados con el bajo rendimiento académico, la desmotivación y el absentismo observado especialmente en los ciclos de grado medio de Formación Profesional. Estos problemas se presentan en frecuentes distracciones e interrupciones constantes de los alumnos en clase, faltas de asistencia, particularmente en las últimas horas de las jornadas, y bajos resultados de aprendizaje en las pruebas de evaluación parcial realizadas. Para ello, se propone la utilización de la metodología de aprender enseñando en combinación con el uso de Aprendizaje Móvil a través de la aplicación TutoApp [5]. Con esta herramienta, los estudiantes crean tutoriales y cuestionarios desde sus teléfonos móviles, con el doble objetivo de comprender para sí mismos los contenidos trabajados en los módulos profesionales, siendo capaces de ayudar a otros compañeros a aprenderlos a través de sus propios tutoriales elaborados; se basa en la metodología de aprender enseñando a través de la tecnología móvil, donde los estudiantes se involucran activamente en el proceso de aprendizaje personal y del grupo.

Este trabajo está organizado en 5 secciones: la sección II presenta el contexto y descripción del artículo; la sección III muestra los resultados obtenidos en la experiencia; la sección IV discute los resultados y los compara con estudios recientes de la literatura; finalmente, la sección V muestra las principales conclusiones y los trabajos futuros.

II. Contexto y descripción

A. *Objetivos*

Este estudio utiliza un diseño cuasiexperimental que busca determinar si se producen cambios significativos en las variables dependientes (Tabla II), antes y después de la experiencia entre los estudiantes, pertenecientes a la etapa preuniversitaria de Formación Profesional, del grupo de control y el grupo experimental. Para ello se plantean tres hipótesis que guían el trabajo:

H1: El trabajo con TutoApp junto con la metodología aprender enseñando mejora los resultados de aprendizaje respecto trabajo tradicional de los estudiantes; entendido este último como explicaciones de contenidos por parte del docente, donde los estudiantes toman apuntes y realizan ejercicios prácticos relacionados (individualmente o en parejas).

H2: Las emociones positivas de los estudiantes, que emplean la metodología aprender enseñando con TutoApp, tras la intervención, son mayores que los estudiantes que no utilizan un método tradicional (clase magistral con ejercicios prácticos).

H3: El perfil de los estudiantes afecta a los resultados de aprendizaje y a sus emociones.

El perfil, hace referencia a las características de los estudiantes, tales como: motivos para elegir sus estudios, razones por las que asistir a clase, género, edad y nivel del grado que estudian.

B. *Contexto*

La población de estudio se trata de un subconjunto de estudiantes de Formación Profesional y supone una muestra total de 131 participantes. En concreto, son seis subgrupos de alumnos pertenecientes a la familia profesional de Informática y Comunicaciones (Tabla I), en el Instituto de Educación Secundaria Ciudad Escolar (Madrid); divididos en un grupo de control (GC) y otro de estudio que representan un muestreo experimental (GE). El grupo de control (91 participantes en total), sigue una metodología tradicional y está formado por cuatro subgrupos (Tabla I). En cuanto al grupo experimental (40 participantes en total), utiliza la aplicación TutoApp durante la experiencia y está formado por dos subgrupos (Tabla I). La edad de los participantes oscila entre los 16 y los 30 años.

TABLA I. MUESTRA DE ESTUDIO

	Módulo profesional	Curso/año académico	Núm. alum.
GC	Fundamentos de Hardware (FH)	1º/ 22-23	25
	Desarrollo Web en Entorno Cliente (DWEC)	2º/ 22-23	17
	Montaje y Mantenimiento de Equipos (MME)	1º/ 21-22	25
	Sistemas de Gestión Empresarial (SGE)	2º/ 21-22	24
GE	Montaje y Mantenimiento de Equipos (MME)	1º/ 22-23	22
	Sistemas de Gestión Empresarial (SGE)	2º/ 22-23	18

C. *Variables*

Se definen una serie de variables dependientes vinculadas con las emociones recogidas en los cuestionarios *Academic Emotions Questionnaire* (AEQ) antes y después de la experiencia (Tabla II).

Además, se fijan otras tres variables dependientes para medir y valorar la adquisición de conocimientos: los conocimientos al final de curso (C_FIN), los conocimientos previos (C_PRE) y los conocimientos posteriores (C_POST) a la experiencia (Tabla II).

Así mismo, en relación con las variables independientes, se consideran los elementos que pueden afectar el estado emocional y la adquisición de conocimientos del estudiante, como la metodología de enseñanza utilizada y el perfil de los estudiantes.

TABLA II. VARIABLES DEPENDIENTE.

Emociones:	Antes	Después
Enfado	EN_PRE	EN_POST
Ansiedad	AN_PRE	AN_POST
Aburrimiento	AB_PRE	-
Disfrute	DI_PRE	DI_POST
Esperanza	ES_PRE	-
Desesperanza	DE_PRE	DE_POST
Orgullo	-	O_POST
Vergüenza	V_PRE	V_POST
Emociones positivas con activación	EPA_PRE	EPA_POST
Emociones negativas con activación	ENA_PRE	ENA_POST
Emociones negativas con desactivación	END_PRE	END _POST
Conocimientos pre-post experiencia	C_PRE	C_POST
Conocimientos al finalizar el curso	-	C_FIN

Algunas emociones se tratan de manera agrupada: las emociones positivas con activación son el resultado de los valores medios de las emociones de disfrute, esperanza y orgullo; las emociones negativas con activación, la media de las emociones enfado, ansiedad y vergüenza; y las emociones negativas con desactivación se atribuyen al promedio de los niveles emocionales experimentados por la desesperación y el aburrimiento.

D. *Instrumentos*

Los instrumentos utilizados para la recogida de los datos que nos permiten comprobar la hipótesis planteada son los siguientes:

- Cuestionarios pre-post test de emociones. Se trata del cuestionario *Academic Emotions Questionnaire*, modelo de Pekrun [6] para estudiar las emociones, ya valorado y utilizado en contextos educativos [7, 8, 9].
- Cuestionarios para valorar el aprendizaje de los contenidos trabajados. Estos cuestionarios son iguales antes y después de la experiencia y están diseñados por el docente que imparte los contenidos de los módulos profesionales. Constan de 20 preguntas de opción múltiple relacionadas con los contenidos técnicos de trabajo. Cada pregunta correcta completamente se valora con 0.5 puntos, pudiendo conseguir una calificación máxima de 10 puntos.

Calificaciones al finalizar el curso para los módulos de estudio, estas calificaciones son los resultados promedio de las valoraciones obtenidas en los tres trimestres del curso escolar, para obtener la puntuación de cada trimestre se sigue la evaluación continua; así, se realizan diferentes pruebas de conocimientos prácticos, a través de cuestionarios, preguntas cortas y supuestos prácticos. Las notas medias de todas las pruebas realizadas durante el trimestre (60% de la nota), más los trabajos prácticos realizados durante el mismo (40% de la nota) componen la nota final del trimestre. Cabe destacar, que estos instrumentos de recogida de datos no recogen datos sensibles ni personales, tan solo el perfil del estudiante y un email ficticio, asignado previa y unívocamente a cada participante, que permite relacionar todas las respuestas de los cuestionarios garantizando la anonimidad. En el caso de las calificaciones finales, se recogen exclusivamente los valores numéricos registrados por los docentes responsables de los módulos estudiados en los cursos correspondientes, por lo que igualmente se garantiza el anonimato de los participantes.

III. RESULTADOS

Para estimar los resultados de los conocimientos al finalizar el curso (variable dependiente C_FIN, Tabla II), previamente se recogen las calificaciones finales obtenidas por los participantes que estudian los módulos profesionales

MME y SGE (Tabla I) en cursos consecutivos (curso actual y 21-22); a continuación, se calcula la media (M), la desviación estándar (DE) y se realiza la prueba Shapiro-Wilk [10] para determinar si se trata de una distribución de datos normal o no. Se aprecia (Tabla III) que, en los dos módulos, tanto el que trabaja el módulo de Montaje y Mantenimiento de Equipos (MME) como el módulo de Sistemas de Gestión Empresarial (SGE) se obtiene una media superior en el grupo experimental. Estas diferencias entre el grupo experimental y el grupo de control apuntan un mayor dominio de los conocimientos al finalizar el curso del grupo que utilizó TutoApp, en comparación con el grupo de control que utilizó un enfoque tradicional.

TABLA III. ESTADÍSTICA DESCRIPTIVA (MANN-WHITNEY) DE CONOCIMIENTOS (MM3 Y SGE) AL FINALIZAR EL CURSO.

		GC (N=49)		GE (N=40)	
		M	DE	M	DE
MME	C_FIN	5.28	1.46	6.64	1.36
SGE	C_FIN	6.46	1.44	6.94	0.99

En cuanto a los resultados del análisis de los conocimientos al finalizar la experiencia, se centran en el estudio de las variables dependientes C_PRE y C_POST (Tabla II). Ahora, la muestra de estudio se compone de estudiantes que trabajan módulos diferentes (GC: FH y DWEC; GE: MME y SGE) en el curso actual (22-23), por eso, conviene aclarar que a pesar de ser módulos de conocimientos diferentes tienen una complejidad similar y en el análisis de los conocimientos previos de todos los subgrupos, se obtuvieron medias aproximadas (GC: 3.74 y GE: 3,63, Tabla IV), por lo que se puede asumir que se parte de situaciones equivalentes. Para el análisis de estas variables, nuevamente, se calcula la media, la desviación estándar y se comprueba con Shapiro-Wilk que se trata de una distribución de datos no normal para los conocimientos previos y distribución normal para conocimientos posteriores. En la Tabla IV se observa que hay diferencia en los conocimientos posteriores a la experiencia entre el grupo de control y el grupo experimental, mejorando en este último.

TABLA IV. ESTADÍSTICA DESCRIPTIVA DE CONOCIMINETOS PRE-POST EXPERIENCIA.

	GC (N=42)		GE (N=40)	
	M	DE	M	DE
C_PRE	3.74	1.32	3.63	0.63
C_POST	6.04	1.16	7.23	1.07

Además, se revisan las posibles diferencias, con respecto al perfil a través del test Kruskal-Wallis, obteniendo que no existen diferencias significativas entre los grupos en cuanto a las pruebas de conocimientos previos y posteriores por perfil; mostrándose en todos los casos significaciones asintóticas, con nivel de significación de 0.05. Los valores de significación se han ajustado mediante la corrección Bonferroni.

Cabe señalar también en relación con los conocimientos adquiridos tras la experiencia y previamente a la misma, que todos los participantes han mejorado los conocimientos en el post-test respecto al pre-test.

Respecto al estudio de las variables relacionadas con las emociones antes y después de la experiencia (Tabla II), la muestra de estudio es exactamente la misma que para el estudio de las variables de conocimientos antes y después de la experiencia, e igualmente se procede de forma similar. Con los datos recogidos antes y después de la experiencia en los Cuestionarios de Emociones Académicas (AEQ), se calcula la media y la desviación estándar o desviación típica de la muestra. También, para determinar la distribución que siguen estas variables, se realiza la prueba de normalidad Shapiro- Wilk con un margen de error del 5% (significancia del 0.05); utilizando la prueba paramétrica t-Student [11] con prueba Levene (igualdad de varianza) para las que siguen distribución normal, mientras que se emplea la prueba Mann- Whitney para las que no siguien distribución normal.

En la Tabla V se recogen estos datos, no observándose diferencias significativas en ninguna de las variables. También, se analiza la existencia de diferencias significativas en la emociones previas y posteriores con respecto a las variables de perfil (ANOVA de un factor de Kruskal-Wallis [12]). No obteniéndose diferencias significativas en ningún caso.

TABLA V. ESTADÍSTICA DESCRIPTIVA DE EMOCIONES (MANN-WHITNEY Y T-STUDENT), PRE-POST EXPERIENCIA

	GC (N=42)		GE (N=40)		
	M	DE	M	DE	Sig.
EN_PRE	2.31	0.74	2.09	0.68	*0.17
AN_PRE	1.70	0.72	1.90	0.82	0.25
AB_PRE	1.98	0.64	1.95	0.64	0.81
DI_PRE	3.67	0.82	3.83	0.64	0.39
ES_PRE	3.83	0.78	3.77	0.75	0.55
DE_PRE	2.33	1.17	2.18	1.11	0.57
V_PRE	2.21	0.84	2.20	0.56	0.67
EPA_PRE	3.75	0.69	3.80	0.54	*0.73
ENA_PRE	2.07	0.53	2.06	0.51	*0.93
END_PRE	2.15	0.67	2.07	0.73	0.40
EN_POST	2.10	0.82	1.90	0.47	0.19
AN_POST	1.95	0.54	2.08	0.44	0.20
DI_POST	3.36	0.86	3.47	1.26	*0.65
DE_POST	1.93	0.66	1.91	0.64	0.95
O_POST	3.56	1.01	3.52	0.85	0.93
V_POST	2.08	0.82	2.24	1.12	0.96
EPA_POST	3.45	0.82	3.49	0.99	*0.85
ENA_POST	2.33	0.53	2.29	0.54	*0.73
END_POST	1.93	0.66	1.91	0.64	0.95

a. * t-Student.

Por último, se realiza un nuevo análisis de correlación entre emociones, que permita entender la relación entre determinadas emociones antes de la experiencia y cómo varían después de la misma, de manera que determine si existe relación entre la metodología utilizada y las emociones experimentadas. En la Tabla VI se presentan los cambios más significativos.

TABLA VI. CORRELACIÓN ENTRE EMOCIONES DESPUÉS Y ANTES DE LA EXPERIENCIA

Disfrute post-pre	GC	GE
O_(POST, PRE)	****0.53**	****0.67**
V_(POST, PRE)	(****-0.61**, 0.20)	(****-0.59**, 0.12)

a. **La correlación es significativa en el nivel 0.01 (bilateral).

Del análisis se deduce que hay una fuerte correlación entre el disfrute y las emociones de orgullo y vergüenza tras la experiencia; ocurre en ambos grupos, aunque en mayor magnitud en el caso del grupo experimental.

IV. Discusión

En relación con las hipótesis planteadas se llega a las siguientes conclusiones.

En relación a la hipótesis *H1: El trabajo con TutoApp junto con la metodología aprender enseñando mejora los resultados de aprendizaje respecto trabajo tradicional de los estudiantes*, a partir de la Tabla III se observa que el grupo experimental obtiene mejores resultados generales al finalizar el curso, es decir, las medias obtenidas por el grupo experimental (6.64 y 6.94) son más altas que las medias obtenidas por el grupo de control (5.28 y 6.46, respectivamente) al finalizar el curso. Por tanto, con la metodología aprender enseñando mediante TutoApp, se produce una ganancia de aprendizaje al finalizar el curso, lo que se traduce en un mejor rendimiento académico frente al grupo de control que utiliza un enfoque tradicional.

Así mismo, de la Tabla IV se muestra que la diferencia entre las medias de los conocimientos previos a la experiencia es muy baja (GC: 3.74 y GE: 3.63), por lo que se puede entender que los grupos parten de circunstancias similares; sin embargo, hay diferencia con respecto a los conocimientos posteriores tanto en el grupo de control (6.04) y el grupo experimental (7.23), mejorando aparentemente en mayor medida en el grupo que utiliza aprender enseñando con TutoApp. Por todo, se acepta la H1 y se considera que el trabajo con TutoApp a través de la metodología de aprender enseñando, mejora el aprendizaje de los estudiantes en relación con los estudiantes que utilizan una metodología tradicional basada en clases magistrales.

En relación a la hipótesis *H2: Las emociones positivas de los estudiantes, que emplean la metodología aprender enseñando con TutoApp, tras la intervención, son mayores que los estudiantes que no utilizan un método tradicional (clase magistral con ejercicios prácticos),* como puede verse en la Tabla V, no se observan grandes diferencias en ninguna de las variables emocionales, de lo que se deduce que las emociones no han variado en los grupos de estudio a pesar del cambio metodológico. Por lo tanto, se rechaza la H2 por lo que se puede entender que las emociones positivas de los estudiantes que utilizan TutoApp con la metodología aprender enseñando tras la intervención no son mayores que los estudiantes que no utilizan la herramienta.

Finalmente, en relación a la hipótesis *H3: El perfil de los estudiantes afecta a los resultados de aprendizaje y a sus emociones*, en las pruebas realizadas para determinar la existencia de diferencias significativas en los conocimientos y emociones previas y posteriores con respecto a las variables de perfil, no se obtienen diferencias significativas; refutando así la hipótesis H3, con lo que el perfil de los estudiantes no afecta a los resultados de aprendizaje ni a sus emociones.

También, el análisis de correlación entre emociones (Tabla VI), determina una fuerte correlación entre el disfrute y las emociones de orgullo y vergüenza tras la experiencia que ocurre en ambos grupos, control y experimental.

Aunque el uso de la aplicación TutoApp en investigaciones académicas, puede considerarse limitado, se encuentran otros trabajos relacionados con el aprendizaje móvil y la metodología de aprender enseñando. Así, en el trabajo de Mojarro [13] sobre Aprendizaje Móvil en la Educación Superior, se observa que el rendimiento esperado ejerce una influencia más significativa en la intención de uso de los hombres en comparación con las mujeres; y además, dicha influencia es mayor en los estudiantes más jóvenes que en los de mayor edad. Algo que no sucede en el presente trabajo, ya que el perfil de los participantes no afecta al rendimiento de los mismos. También, en el estudio de J. M.

Romero-Rodríguez et al. [14], sobre la influencia de los dispositivos móviles en el rendimiento académico y la autorregulación del aprendizaje en estudiantes universitarios, los resultados muestran una influencia significativa del género en el uso de dispositivos móviles y su relación con la

autorregulación del aprendizaje. Sin embargo, no se encuentra una influencia significativa en el rendimiento académico.

Asimismo, se encuentra relación con el trabajo de Gordillo [15], que lleva a cabo un proyecto en las aulas de Formación Profesional Básica, consistente en generar contenido audiovisual y difundirlo en redes sociales y entornos web. Este trabajo de Gordillo concluye que el alumnado mejora su rendimiento académico y las competencias emocionales básicas, aumentando los niveles de bienestar emocional, autoestima y posicionamiento social. En la misma línea, se identifican similitudes con la investigación de Ribosa y Durán [16], donde parejas de estudiantes elaboran videotutoriales cooperativos a partir de preguntas planteadas por ellos mismos y cuyos resultados muestran mejoras significativas en el conocimiento específico del contenido, un grado adecuado de elaboración de explicaciones y la capacidad de recordar ideas concretas de la explicación.

V. Conclusiones

Este trabajo presenta la realización de una intervención en el aula de Formación Profesional, introduciendo el aprendizaje a través de la aplicación TutoApp para dispositivos Android. Se base en la metodología de aprender enseñando a través de la tecnología móvil, donde los estudiantes se involucran activamente en el proceso de aprendizaje personal y del grupo.

Para evaluar la repercusión de esta experiencia sobre los 131 participantes en cuanto a los conocimientos adquiridos se realizan dos análisis. Por un lado, se realiza la comparación entre un grupo de control (49 participantes) y otro experimental (40 participantes) en los que se trabajan los mismos conceptos a través de diferentes metodologías (enfoque tradicional vs. aprender enseñando con TutoApp) y se analizan sus resultados al finalizar el curso completo. En un segundo análisis se realiza la comparación entre grupos (control con 42 participantes frente a experimental con 40 participantes) que no solo utilizan distinta metodología (tradicional vs. TutoApp), sino que también trabajan distintos contenidos técnicos durante la intervención de aula, si bien estos contenidos son de dificultad similar. Estos contenidos técnicos, aunque son distintos, tienen relación por su ámbito de estudio y una complejidad similar en todos los casos; se refieren a saberes prácticos sobre cómo montar equipos informáticos, cómo centralizar la gestión de una empresa o cómo añadir interactividad a una página web entre otros. Así mismo, la variedad en cuanto al perfil de los participantes (motivos por los que eligen sus estudios, razones por los que asisten a clase, género, edad y nivel del grado) se tiene en cuenta en el análisis.

Entre los principales hallazgos, se observa una diferencia en los subgrupos experimentales que trabajan con TutoApp, demostrando un mayor dominio de los conocimientos al finalizar el curso en comparación con el grupo de control que utiliza un enfoque tradicional. Esto sugiere que la implementación de TutoApp en el proceso de enseñanza y aprendizaje puede mejorar el aprendizaje de los contenidos.

Además, en el análisis centrado en la intervención, no se encuentran grandes diferencias en los conocimientos previos a la experiencia entre los grupos de estudio, lo que indica que ambos grupos parten de circunstancias similares. Sin embargo, se encuentra una diferencia en los conocimientos adquiridos después de la experiencia, donde el grupo experimental que utiliza TutoApp logra un mayor nivel de dominio de los contenidos en comparación con el grupo de control; lo que parece reforzar lo citado anteriormente, el uso de TutoApp mejora los resultados académicos después de la experiencia.

En cambio, en cuanto a las emociones, no se encuentran diferencias significativas entre los grupos de estudio. Esto sugiere que el cambio en la metodología no tiene un impacto significativo en las emociones experimentadas por los estudiantes. Por tanto, conocidos estos hallazgos se puede concluir que los resultados proporcionan evidencia de los beneficios de esta metodología en el contexto concreto de la Formación Profesional para la muestra de estudio.

Respecto a trabajos futuros, se plantea realizar un análisis estadístico inferencial más profundo que determine si las diferencias encontradas en la adquisición de conocimiento son significativas. También se sugiere que la investigación no se limite únicamente a la utilización de TutoApp como una herramienta para mejorar la adquisición de los contenidos trabajados en las clases, ya que se puede considerar la creación de tutoriales con TutoApp para fomentar la creatividad, la autonomía, la capacidad de comunicación de los estudiantes, es decir, un enfoque más centrado en el estudiante y en el desarrollo de habilidades específicas, en lugar de enfocarse en la transmisión de conocimientos; o incluso, en la mejora de la inclusión y la accesibilidad en el aula. En último término, cabe destacar la posibilidad de valorar cómo la creación de tutoriales con TutoApp es integrada en diferentes disciplinas y materias, y cómo se adapta a diferentes niveles y etapas educativas en las que todavía no se ha explorado (primaria, secundaria y bachillerato).

AGRADECIMIENTOS

Maximiliano Paredes-Velasco quiere agradecer el apoyo del proyecto-puente PROGRAMA de la Universidad Rey Juan Carlos con referencia M3035.

REFERENCIAS

[1] M. J. Martínez Usarralde, "¿Hacia la consolidación de un proyecto europeo?: problemas, obstáculos e inconvenlentes de la Formación profesional en la Unión Europea," 2001.

[2] L. Buitron, J. Ortiz-Herrera, S. Cadena-Vela and M. Cárdenas, "Hallazgos sobre el proceso de formación profesional en áreas sociales y ciencias básicas, en época de covid-19," *IV Congreso Internacional de la Universidad Nacional de Educación,* pp. 69-82, 5 2022.

[3] G. G. Castro, N. R. Mero and J. M. Valencia, "Problemas socioeconómicos y su incidencia en la formación profesional ante la pandemia COVID-19," *Revista Imaginario Social,* vol. 5, 2022.

[4] D. Duran, "Aprenseñar: Evidencias e implicaciones educativas de aprender enseñando," *Articles: Revista de didàctica de la llengua i de la literatura,* p. 79–81, 2014.

[5] I. Lozano-Osorio, *TutoApp Apk,* 2023.

[6] R. Pekrun, "The Control-Value Theory of Achievement Emotions: Assumptions, Corollaries, and Implications for Educational Research and Practice," *Educational Psychology Review,* vol. 18, p. 315–341, 11 2006.

[7] T. D. Fonseca and G. Acle-Tomasini, "Construcción de una Escala para Evaluar Emociones de Logro en Estudiantes de Primaria," *Revista Iberoamericana de Diagnóstico y Evaluación – e Avaliação Psicológica,* vol. 61, p. 99–115, 10 2021.

[8] M. Paredes-Velasco, I. Lozano-Osorio, D. Perez- Marin and L. P. Santacruz-Valencia, "A Case Study on Learning visual programing with TutoApp for Composition of Tutorials: An approach for Learning by Teaching," *IEEE Transactions on Learning Technologies,* p. 1–16, 2022.

[9] R. Pekrun, H. W. Marsh, F. Suessenbach, A. C. Frenzel and T. Goetz, "School grades and students' emotions: Longitudinal models of within-person reciprocal effects," *Learning and Instruction,* vol. 83, p. 101626, 2 2023.

[10] P. E. McKnight and J. Najab, "Mann-Whitney U Test," *The Corsini encyclopedia of psychology,* p. 1– 1, 2010.

[11] R. A. Sánchez Turcios, "t-Student: Usos y abusos," *Revista mexicana de cardiología,* vol. 26, p. 59–61, 2015.

[12] L. St, S. Wold and others, "Analysis of variance (ANOVA)," *Chemometrics and intelligent laboratory systems,* vol. 6, p. 259–272, 1989.

[13] Á. Mojarro Aliaño, "Mobile learning en la Educación Superior : una alternativa educativa en entornos interactivos de aprendizaje," 2019.

[14] J. M. Romero-Rodríguez, I. A. Díaz, F. J. Hinojo- Lucena and G. Gómez-García, "Uso de los dispositivos móviles en educación superior: relación con el rendimiento académico y la autorregulación del aprendizaje," *Revista Complutense de Educación,* vol. 32, p. 327–335, 4 2021.

[15] R. Gordillo Durán, *Aprender enseñando,* 2022.

[16] J. Ribosa and D. Duran, "Cuando la curiosidad científica se transforma en un videotutorial para aprender enseñando: conocimiento del contenido, elaboración de las explicaciones y complejidad de las preguntas," *Revista Iberoamericana de Educación,* vol. 87, p. 85–102, 11 2021.

Uso de Modelo Grande de Lenguaje en un curso de Bases de Datos: una visión vía TAM

Using an LLM in a Database course: the TAM view

Manuel Palomo-Duarte
Departamento de Ingeniería Informática
Universidad de Cádiz
Puerto Real, Spain
manuel.palomo@uca.es

Rubén Baena-Pérez
Departamento de Ingeniería Informática,
Universidad de Cádiz
Puerto Real, Spain
ruben.baena@uca.es

Antonio Balderas
Departamento de Ingeniería Informática,
Universidad de Cádiz
Puerto Real, Spain
antonio.balderas@uca.es

Juan Antonio Caballero-Hernández
Departamento de Ingeniería Informática,
Universidad de Cádiz
Puerto Real, Spain
juanantonio.caballero@uca.es

Andrés Munoz
Departamento de Ingeniería Informática,
Universidad de Cádiz
Puerto Real, Spain
andres.munoz@uca.es

Juan Manuel Dodero
Departamento de Ingeniería Informática Universidad de Cádiz
Puerto Real, Spain
juanma.dodero@uca.es

***Resumen*—The adoption of Generative Artificial Intelligence systems has made a disruptive change in digital content production of different kind. Beyond its implications for business context, the academia has also been affected, specially in autonomous learning and handout creation. Nevertheless, other than ethical issues, there is a practical aspect underneath: these systems are based on statistical models, and thus prone to unexpected failures in their output. As a consequence, users have to make a critic review of the system proposals. In this paper we introduce an experience conducted in a Database course of a Computer Science degree. Students had to review the output produced by BingChat for an exam on relational database design that they had previously made in the course. Students also filled a Technology Acceptance Model questionnaire sharing their experience. Results show a general positive attitude towards the system, but reluctant to a its adoption without a proper previous training.**

***Resumen*— La adopción de Inteligencias Artificiales Generativas ha revolucionado la producción de contenidos digitales de diverso tipo. Más allá´ de su adopción en contextos empresariales, en la academia ha afectado mucho al trabajo autónomo y realización de proyectos. Sin embargo, más allá´ de temas éticos, hay un trasfondo práctico importante, pues son sistemas basados en métodos estadísticos y sujetos a fallos inesperados en su salida. Es por ello que sus usuarios deben ser críticos con las propuestas de estos sistemas y tener capacidad para evaluarlas. En este artículo presentamos una experiencia desarrollada en una asignatura de Bases de Datos del Grado en Ingeniería Informática, en la que se pedía a los alumnos revisar la salida que proporcionaba BingChat al enunciado de un examen sobre diseño de bases de datos relacionales que se realizó previamente en la asignatura. Los alumnos además completaron un cuestionario Technology Acceptance Model para expresar su parece con la experiencia. Los resultados en general mostraron una actitud positiva hacia la herramienta pero con ciertos reparos a su uso sin una formación previa adecuada.**

***Index Terms*—Generative Artifical Intelligence, Large Language Models, Technology Acceptance Model, Relational Databases.**

Este trabajo ha sido desarrollado en el contexto del proyecto CREˆPES (ref. PID2020-115844RB-I00), financiado por la Agencia Estatal de Investigación del Ministerio de Ciencia e Innovación de España con fondos ERDF.

I. Introducción

Desde el lanzamiento del asistente conversacional ChatGPT por parte de OpenAI en noviembre de 2022, la adopción de sistemas basados en Inteligencias Artificiales generativas (basadas en LLM, *Large Language Model*) han sido ampliamente adoptadas en entornos de todo tipo, especialmente por su facilidad de uso (pues interactúan en lenguaje natural), su licencia abierta en muchos casos [1] y los resultados tan ”completos” que ofrecen, siendo un comportamiento disruptivo respecto a herramientas previas [2]. Su llegada ha provocado reacciones diversas, siendo incuestionables los problemas éticos que suscita su uso [3]. De hecho, diversos países están considerando limitar su acceso por sus implicaciones en la privacidad de los ciudadanos [4]. En cuanto a su impacto en empresas, se han producido reacciones de todo tipo: mientras que algunas empresas han reconocido públicamente que la adopción de estas herramientas les ha ayudado a ser más competitivas [5], otras muestran recelo [6]. De cualquier modo, las cifras ac- tuales muestran efectos innegables a corto plazo en el empleo y actividad económica [7].

En lo relativo a su uso educación, los asistentes conversacionales basados en IA también ha tenido una adopción inmediata [8]. Es remarcable que en el caso de otras tecnologías previas, los países hispanoparlantes han adolecido un cierto retraso al adoptarlas, especialmente por la barrera idiomática. Sin embargo, algunos asistentes como ChatGPT han proporcionado una interfaz en español desde su lanzamiento, lo que ha reducido la brecha entre América Latina y otras regiones más desarrolladas [9].

Aunque son innegables las posibilidades que ofrece en procesos educativos tanto para docentes como para estudian- tes [10], algunas instituciones regularon su uso, principal- mente para evitar plagios [11]. Además, su uso inadecuado (tanto por estudiantes como por docentes) puede producir situaciones delicadas [12]. Estas situaciones pueden darse con más facilidad al usar estos sistemas, pues están basados en métodos estadísticos y sujetos a fallos inesperados en su salida. Entre otros problemas, sus respuestas pueden reflejar determinados sesgos de su conjunto de datos de entrenamiento o directamente realizar afirmaciones falsas (lo que se conoce como *alucinar*) [13]. Esto es especialmente preocupante en el caso de los estudiantes de Ingeniería Informática, quienes pueden diseñar sistemas informáticos que se usen en entornos reales donde determinados errores puedan provocar cuantiosas pérdidas económicas [14] o incluso de vidas humanas [15].

En este trabajo, presentamos una experiencia en la que se les solicito´ a los alumnos que revisaran la respuesta que proporcionaba BingChat a las preguntas de un examen que habían realizado previamente en una asignatura de Bases de Datos en la Universidad de Cádiz. Además, los alumnos completaron un cuestionario basado en el Technology Acceptance Model (TAM) para expresar su opinión sobre la experiencia

El resto del documento tiene la siguiente estructura: el capítulo 2 revisa trabajos relacionados. El capítulo 3 explica la metodología seguida en el experimento. El capítulo 4 discute los resultados obtenidos. Y, por último, el capítulo 5 resumen las conclusiones y comenta los trabajos futuros.

II. Trabajos relacionados

Debido a lo reciente de la tecnología que se ha usado, son escasos los trabajos relacionados profundamente con la temática. De hecho, se ha tenido que recurrir a repositorios de literatura gris (Arxiv.org) para recopilar algunos.

Una experiencia de uso de ChatGPT y BingChat en ensenanaza de química indica que estos sistemas ayudan a reflexionar al alumnado, desarrollando el pensamiento crítico, la resolución de problemas, la comprensión de conceptos y la personalización de la experiencia de aprendizaje [16].

Otros resultados interesantes pueden obtenerse de la comparación del sistema de apoyo al desarrollo de código GitHub Copilot dirigido por una IA generativa y sistemas de programación genética [17]. En concreto, aunque los resultados son similares en un banco de pruebas, GitHub Copilot responde mejor a las necesidades de los desarrolladores. Es más, parece que las aproximaciones de programación genética necesitan mucho más entrenamiento, etiquetado de código y aún así sus soluciones parecen más complejas (”artificiales”).

Sin embargo, en otro artículo [18] se indica que compara GitHub Copilot con un humano que hace programación por pares (*pair programming*). Tras revisar un experimento con

21 participantes, se llega a la conclusión de que aunque GitHub Copilot mejora la productividad en líneas de código

incorporadas, la calidad de este es inferior a la que se produce con un humano.

En [19] se usa ChatGPT para que alumnos que aprenden español como segundo idioma interactúen con él. En otros aspectos importantes, se indica que aunque los textos genera- dos por ChatGPT suelen ser gramaticalmente correctos comete muchos errores en estilo, ortografía y diversidad cultural mostrando una influencia de idioma inglés

III. Metodología

Como se comentó´ anteriormente, el objetivo del experimento es evaluar si los alumnos tienen capacidad crítica para usar una Inteligencia Artificial generativa en sus clases. En concreto, se decidió´ seguir los siguientes pasos:

1. El profesor pide, en una primera y única interacción con BingChat, que genere un modelo de datos relacional para un problema de tamaño medio del ámbito de la asignatura de Bases de Datos que se realizó´ como examen.
2. El profesor recibe la respuesta de BingChat y la formatea adecuadamente para que la puedan interpretar los alumnos.
3. Los alumnos reciben en formato papel tanto el enuncia- do como la respuesta proporcionada por BingChat, con objeto de revisarla.
4. Los alumnos corrigen en la respuesta de BingChat los errores detectados.
5. Los alumnos rellenan una encuesta Technology Acceptance Model (TAM).
6. Los alumnos tienen posibilidad de expresar su opinión sobre la experiencia en un cuadro texto.
7. Tras la experiencia se analizaron las respuestas al cuestionario y se leyeron los comentarios libres que hicieron los alumnos.

De esta forma, el objetivo de esta experiencia no es que los alumnos interactúen con BingChat, sino que (1) demuestren si están capacitados para encontrar fallos en la primera interacción con el sistema. De este modo se podría plantear realizar iteraciones adicionales para que refinara su salida, y/o se use dicha salida con posibles modificaciones con fines profesionales. Y (2) expresen su actitud sobre la posible adopción de la herramienta en su enseñanza.

IV. Estudio de caso

El estudio de caso presenta los resultados en la asignatura Bases de Datos, obligatoria en segundo curso del Grado en Ingeniería Informática de la Universidad de Cádiz (España). Las bases de datos son uno de los contenidos básicos en los estudios de Ingeniería Informática en España, reconocidos como tal en el Libro Blanco del Título de Grado en Ingenier´ıa de la ANECA [20].

En esta asignatura, entre otras competencias, se trabaja (1) la capacidad del alumnado para realizar diagramas conceptuales (E/R) a partir de requisitos de datos y (2) la capacidad para, a partir de dichos diagramas conceptuales, generales modelos lógicos relacionales adecuados. Tras varias pruebas, el profesorado de la asignatura eligió la herramienta BingChat por su capacidad para realizar estas dos tareas de manera totalmente automática y encadenada: a partir de unos requisitos textuales generar un modelo lógico relacional que los satisfaga sin necesidad de construir un diagrama conceptual intermedio.

En concreto, se usó para la prueba el enunciado del primer examen parcial de la asignatura, que los alumnos habían realizado unos dos meses antes. El enunciado fue redactado para que tuviera una solución concreta que, sin llegar a ser un problema de solución única, sí que tiene poco margen de maniobra para la interpretación.

El profesor utilizó la versión de BingChat disponible en el momento de realizar el estudio (10 de abril del 2023). Se recibieron 3 soluciones, de acuerdo a las personalidades disponibles del chat: equilibrada, creativa y estricta. En concreto, las indicaciones fueron:

- Actúa como: Analista de base de datos
- Tarea: Creación del código DDL a partir de una descripción de las reglas de negocio
- Requisitos: base de datos MySQL, código en lenguaje SQL, idioma español, código comentado
- Reglas de negocio: [... enunciado del problema ...]

Los 55 alumnos que asistieron a clase recibieron al azar una de las tres soluciones proporcionadas por BingChat y, como tarea de la asignatura, la revisaron en una sesión de una hora de seminario de teoría.

Se indicó a los alumnos que dicha tarea tendría la nota máxima simplemente por entregarla, para evitar que colaboraran con otros compañeros en su resolución.

El cuestionario TAM que realizaron los alumnos fue una traducción al español de los ítems mostrados en la Tabla I. Se respondió a cada uno en una escala likert de 1 (Totalmente en desacuerdo) a 5 (Totalmente de acuerdo) para las siguientes categorías:

- Perceived Usefulness (PU)
- Social Norm (SN)
- Behavour Intention (BI)
- Attitude Towards Using (ATT)
- Actual Use (AU)

V. Análisis de resultados

En la tabla I se pueden observar las medias y dispersiones de cada ítem del cuestionario.

Respecto a la Utilidad Percibida (PU), los alumnos afirman claramente que BingChat les permitió´ completar el ejercicio de manera más rápida (PU1), que su salida es fácil de entender (PU6). Los demás ´ítems se mueven en el rango 2,69 (PU5 y PU7) y 3,38 (PU3), con una desviación muy significativa en el rango $[0,82-1,17]$

En cuanto a las normas sociales (SN), ven al profesorado en contra de usarlo (2,07) y también algo en contra la visión de uso en general (2,36). Pero sí que consideran que los alumnos ven su uso como algo positivo (3,27). Todos estos valores de nuevo con una dispersión significativa en torno a 1 punto.

Cuadro I
Tabla de datos del cuestionario TAM

Pregunta	Media		Desv.
PU1 BingChat me ha permitido completar			
el ejercicio de manera más rápida	**3,91**		**1,05**
PU2 BingChat me ha permitido mejorar	**3,00**		**1,07**
la calidad de la solución del ejercicio	**3,38**		**0,97**
PU3 BingChat me ha permitido mejorar			
mi productividad en este ejercicio	**3,33**		**1,14**
PU4 BingChat me ha permitido entender	**2,69**		**0,96**
mejor lo que ped´ıa el ejercicio	**3,87**		**0,82**
PU5 La solución propuesta por BingChat			
parece fiable y tiene sentido	**2,69**		**0,98**
PU6 La solución propuesta por BingChat es	**3,22**		**1,17**
fácil de entender			
PU7 La solución propuesta por BingChat me			
ha parecido satisfactoria			
PU8 Las ventajas de usar BingChat al resolver			
este ejercicio son mayores que las desventajas			
SN1 Mi profesor/a piensa que debemos usar			
BingChat en la asignatura	**2,07**		**0,99**
SN2 Mis compañeros/as piensan que debemos	**3,27**		**1,15**
usar BingChat en la asignatura			
SN3 Usar BingChat para resolver ejercicios en	**2,36**		**1,02**
esta asignatura esta´ bien visto en general			
BI1 Tengo intención de seguir usando			
BingChat en esta asignatura	**2,31**		**1,10**
BI2 Suponiendo que el profesor nos de´ acceso			
e instrucciones de cómo usar BingChat, tengo			
intención de utilizarla como una herramienta			
más en la asignatura	**3,35**		**1,24**
ATT1 Pienso que uso de BingChat en esta			
asignatura es positivo	**3,09**		**1,11**
ATT2 Usar BingChat para resolver ejercicios de	**2,42**		**1,05**
esta asignatura es una buena decisión	**4,05**		**0,78**
ATT3 Revisar el ejercicio resuelto por BingChat			
ha sido entretenido	**2,42**		**0,94**
ATT4 Pienso que BingChat es capaz de resolver			
el ejercicio mejor que yo			
AU1 En tu día a día, ¿cuántas veces has usado			
BingChat para tus tareas de estudio?	**2,35**		**1,08**
AU2 ¿Cuántas veces has usado BingChat para tus	**2,69**		**1,24**
tareas de estudio a la semana?			

Los resultados de intención de comportamiento (BI) muestran poco interés por usarlo por cuenta propia (2,31), pero se muestran muy positivos a usarlo con formación previa (3,35, aunque con una dispersión de 1,24).

En el ´ítem actitud a usarlo (ATU) piensan que ha sido positivo usarlo (3,09) y una gran unanimidad en que ha sido divertido corregir a BingChat (4,05). Sin embargo, pocos consideran que sea buena idea confiar en el sistema para resolver ejercicios de la asignatura ni que lo haga mejor que ellos (2,42 en ambas preguntas).

Si nos fijamos en el detalle de los ´ítems AU1 (En tu día a día, ¿cuántas veces has usado BingChat para tus tareas de estudio?, fig. 1) y AU2 (¿Cuántas veces has usado BingChat para tus tareas de estudio a la semana?, ver Fig. 2) vemos un efecto curioso. Los alumnos que usan BingChat o similar nunca, habitualmente y casi constantemente mantienen ese comportamiento a nivel diario y semanal (con un 19 %, 21 % y un 7 % respectivamente). Pero del 50 % de alumnos que declara usar diariamente muy poco estas herramientas (*muchos días no las uso*) se reduce a casi la mita (27 %) cuando se les pregunta a nivel semanal (*algunas semanas no lo uso*). Y ese porcentaje pasa en su mayor parte a *casi siempre*, que se incrementa de un 5 % diario a un 22 % semanal. Por lo tanto, parece que hay un grupo importante de alumnos que no necesita este tipo de herramientas en su día a día pero sí puntualmente.

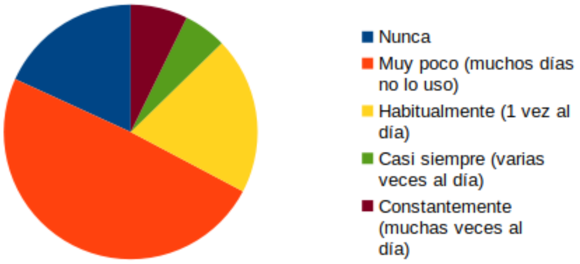


Figura 1. Uso diario.

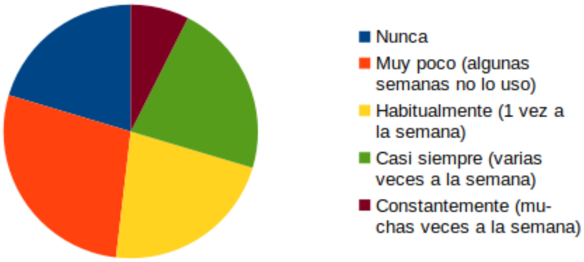


Figura 2. Uso semanal.

VI. Conclusiones y trabajo futuro

En este artículo se han presentado una experiencia en la que alumnos del Grado en Ingeniería Informática revisaron la salida que proporcionaba BingChat al enunciado de un examen sobre diseño de bases de datos relacionales que realizaron previamente en la asignatura. Los alumnos rellenaron un cuestionario Technology Acceptance Model para expresar su opinión con la experiencia.

Los resultados, por lo general, muestran una actitud positiva hacia la herramienta. Los alumnos parecen reconocer que les ha ayudado, aunque recelan de la fiabilidad de esta. Es interesante que también indican que les ayuda a entender mejor lo que el ejercicio les exigía. Esto debería llevar a una reflexión profunda sobre el nivel de competencia de los alumnos adquirido durante desarrollo de la asignatura, ya que esta prueba se realizó en los últimos días de clase.

También reconocen que perciben más recelo hacia el uso de estas herramientas desde la perspectiva de la academia que entre sus compañeros. Sin embargo, estarían interesados en utilizarlas con una formación adecuada. Por último, destacan que consideran que la experiencia de criticar a BingChat ha sido ”entretenida”.

Como trabajo futuro queda hacer un análisis más profundo de los resultados, para identificar correlaciones dentro de las respuestas. También creemos que si se pudiera analizar el resultado de la corrección de cada estudiante y correlacionarlo con su opinión podrían obtenerse conclusiones más finas sobre la experiencia.

Agradecimientos

Este trabajo ha sido financiado parcialmente por el proyecto CREˆ PES (ref. PID2020-115844RB-I00), financiado por la Agencia Estatal de Investigación (AEI) usando fondos ERDF.

Referencias

[1] A. Liesenfeld, A. Lopez, and M. Dingemanse, “Opening up chatgpt: Tracking openness, transparency, and accountability in instruction- tuned text generators,” ser. CUI ’23. New York, NY, USA: Association for Computing Machinery, 2023. [Online]. Available: https://doi.org/10.1145/3571884.3604316

[2] B. Marr. (2023) The Best Examples Of What You Can Do With ChatGPT. [Online]. Avai- lable: https://www.forbes.com/sites/bernardmarr/2023/03/01/the-best-examples-of-what-you-can-do-with-chatgpt

[3] P. P. Ray, “ChatGPT: A comprehensive review on background, applications, key challenges, bias, ethics, limitations and future scope,” *Internet of Things and Cyber-Physical Systems*, vol. 3, pp. 121–154, 2023. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S266734522300024X

[4] S. McCallum. (2023) ChatGPT banned in Italy over privacy concerns. [Online]. Available: https://www.bbc.com/news/technology-65139406

[5] A. Tellez. (2023) These major companies are all using ChatGPT – here’s why. [Online]. Available: https://www.forbes.com.au/news/innovation/these-major- companies-are-all-using-chatgpt-heres-why

[6] P. McGlauflin. (2023) Apple, Goldman Sachs, and Samsung among growing list of companies banning employees from using ChatGPT at work. [Online]. Available: https://fortune.com/2023/05/19/chatgpt- banned-workplace-apple-goldman-risk-privacy

[7] T. Williams. (2023) Some companies are already replacing workers with ChatGPT, despite warnings it shouldn’t be relied on for ‘anything im- portant’. [Online]. Available: https://fortune.com/2023/02/25/companies- replacing-workers-chatgpt-ai/

[8] UNESCO, “ChatGPT e inteligencia artificial en la educacio´n superior : gu´ıa de inicio ra´pido ,” UNESCO, Tech. Rep., 2023. [Online]. Available: https://unesdoc.unesco.org/ark:/48223/pf0000385146˙spa

[9] ——. (2023) ChatGPT: Considerations for education in Latin America and the Caribbean. [Online]. Available: https://www.unesco.org/en/articles/chat-gpt-considerations- education-latin-america-and-caribbean

[10] A. Strzelecki, “To use or not to use chatgpt in higher education? a study of students’ acceptance and use of technology,” *Interactive Learning Environments*, vol. 0, no. 0, pp. 1–14, 2023. [Online]. Available: https://doi.org/10.1080/10494820.2023.2209881

[11] A. Williams. (2023) Which London universities ban ChatGPT and AI chatbots? [Online]. Available: https://www.standard.co.uk/tech/london- universities-ban-chatgpt-ai-chatbots-plagiarisation-b1065331.html

[12] U. Ede-Osifo. (2023) College instructor put on blast for accusing students of using ChatGPT on final assignments. [Online]. Available: https://www.nbcnews.com/tech/chatgpt-texas-college- instructor-backlash-rcna84888

[13] M. de Educación de Chile. (2023) Guía para Docentes – Cómo usar ChatGPT para potenciar el aprendizaje activo. [Online]. Available: https://ciudadaniadigital.mineduc.cl/recurso/guia- para-docentes-como-usar-chatgpt-para-potenciar-el-aprendizaje-activo/

[14] M. Zhivich and R. K. Cunningham, "The real cost of software errors," *IEEE Security Privacy*, vol. 7, no. 2, pp. 87–90, 2009.

[15] R. C. Viladrosa. (2014) ¿El error informático más grave de la historia? [Online]. Available: https://blogs.uoc.edu/informatica/el-error- informatico-mas-grave-de-la-historia/

[16] R. P. dos Santos, "Enhancing chemistry learning with chatgpt and bing chat as agents to think with: A comparative case study," 2023.

[17] D. Sobania, M. Briesch, and F. Rothlauf, "Choose your programming copilot: A comparison of the program synthesis performance of github copilot and genetic programming," in Proceedings of the Genetic and Evolutionary Computation Conference, ser. GECCO '22. New York, NY, USA: Association for Computing Machinery, 2022, p. 1019–1027. [Online]. Available: https://doi.org/10.1145/3512290.3528700

[18] S. Imai, "Is github copilot a substitute for human pair-programming? an empirical study," in Proceedings of the ACM/IEEE 44th International Conference on Software Engineering: Companion Proceedings, ser. ICSE '22. New York, NY, USA: Association for Computing Machinery, 2022, p. 319–321. [Online]. Available: https://doi.org/10.1145/3510454.3522684

[19] E. R. Mendoza, "Formular preguntas para comprender las respuestas,"MarcoELE: Revista de Dida´ctica Espan˜ol Lengua Extranjera, no. 36, pp. 1–18, 2023.

[20] V. autores, Libro Blanco.Título de Grado en Ingeniería. ANECA, 2004. [Online]. Available: http://www.aneca.es/var/media/150388/libroblanco _ jun05 informatica.pdf

Assessment of Learning Mediated by Digital Technologies in the Context of Environmental Education: Teacher Training through a MOOC Course

1st George Bassul Areias
Programa de Educação em Ciências e Matemática
Instituto Federal do Espírito Santo
Vila Velha, Brasil
georgebassul@hotmail.com

2st Isaura Alcina Martins Nobre
Programa de Educação em Ciências e Matemática
Instituto Federal do Espírito Santo
Vila Velha, Brasil
isaura.ead@gmail.com

3st Marize Lyra Silva Passos
Programa de Educação em Ciências e Matemática
Instituto Federal do Espírito Santo
Vila Velha, Brasil
marize@ifes.edu.br

Abstract—**Historically, the act of evaluating has become an exclusionary, authoritarian and anti-democratic tradition, being a classificatory and selective mechanism, centered on the educator and the teaching system, not prioritizing who learns. Therefore, we must understand that when evaluating, we need instruments that are diagnostic and guided by equity, thus allowing to provide learning that makes sense to the student, since there is no "truth", but truths that are revealed and validated according to the epistemological, methodological relationship and the current historical moment. Therefore, the present research aims to offer an educational product in a massive and open course format, known as MOOC, thus making it possible to expand the scope of the offer, but optimizing budgetary and temporality issues. The course addresses the concepts of learning assessment, its methods and the use of digital technologies, in a formative perspective in the context of Environmental Education, seeking the integration of traditional doing combined with the insertion of new environments / knowledge through an emancipatory intentionality. The research is linked to the Rio Doce School Program, which aims to provide postgraduate training for educators (teachers, managers and community representatives working in schools) working in public schools of basic education.**

Keywords—learning assessment, digital technologies, environmental education, teacher training, MOOC

I. Introdução

Em meio às necessidades dialógicas entre o que é tradicional e o que é contemporâneo, a educação ambiental torna-se um importante mecanismo de valorização dos saberes e fazeres dos atores envolvidos na ação educativa, ampliando as possibilidades de fortalecimento da autonomia e do empoderamento. Por meio da educação ambiental, o diálogo é favorecido, valorizando o contexto histórico frente a um processo excludente nas relações sociais, políticas e econômicas, além da afetação por intervenções de ordem territorial, promovidas pela implantação de empreendimentos econômicos industriais, desastres ambientais, expansão urbana e políticas municipais.

Nessa perspectiva, a avaliação, em seu sentido amplo, apresenta-se como uma atividade essencialmente humana associada à experiência cotidiana de todos nós. Fazendo parte do nosso dia a dia, muitas vezes determina o nosso modo de ser ou de agir. Sendo assim, quanto mais dialógico for esse processo, mais consciência temos dele, nos constituindo assim, como sujeitos individual e social. Portanto, torna-se importante compreender o porquê das ações que envolvem a avaliação da aprendizagem em muitos momentos ainda ser utilizada como um simples instrumento para medir o progresso dos alunos ao longo do processo educacional.

Diante desse cenário, as tecnologias digitais podem colaborar nos processos avaliativos, tornando-se propulsoras da aprendizagem, favorecendo de maneira transversal a interdisciplinaridade. Além disso, por meio do uso de tecnologias, de maneira consciente e responsável, é possível estimular nos alunos o pensamento crítico, criativo e lógico, tanto no contexto educacional quanto nas tarefas cotidianas.

Portanto, como objetivo inicial, o estudo ofertou uma formação por meio de um Curso MOOC, com conteúdos que auxiliem os educadores na reflexão sobre a avaliação no processo de ensino e aprendizagem, em específico no contexto da educação ambiental, além da orientação e instrumentalização para o uso das tecnologias digitais.

O estudo está amparado pelo Projeto Rio Doce Escolar[1], que é uma parceria entre Instituto Federal do Espírito Santo (Ifes) e Fundação Renova, no qual pretende realizar formação em nível de pós-graduação de educadores (professores, gestores e representantes comunitários atuantes nas escolas) atuantes nas escolas públicas da educação básica em 4 municípios (Baixo Guandu, Colatina, Marilândia e Linhares) localizados na região da bacia do Rio do Doce, no Estado do Espírito Santo, Brasil, integrando atividades de ensino, pesquisa e extensão.

E para fundamentar o diálogo teórico necessário, além desta sessão introdutória, organizamos o estudo em outras 5 (cinco) sessões, a saber: referencial teórico; percurso metodológico; análise e resultados; agradecimentos; e considerações finais.

[1] https://projetoriodoceescolar.ifes.edu.br/

II. Referencial Teórico

Consideramos que o arcabouço teórico-metodológico, enquanto estruturante pedagógico, deve sustentar a organização e a execução de processos educativos e avaliativos, bem como buscar responder a problemática proposta, desenvolvendo com os sujeitos da ação educativa, as capacidades necessárias tanto para compreenderem a complexidade da relação da avaliação no processo de ensino e aprendizagem, quanto para intervirem nesta relação, de modo reflexivo, estruturado e qualificado.

Neste contexto, iremos trabalhar as vertentes da avaliação da aprendizagem a partir da experimentação de diferentes estratégias de como avaliar os resultados alcançados por meio das intervenções práticas, evidenciando o uso de tecnologias digitais e buscando minimizar a dificuldade em estabelecer a relação entre teoria e prática, entre o conhecimento científico e o senso comum, tendo a educação ambiental como área de estudo e conhecimento.

De acordo com as Diretrizes Curriculares Nacionais para a Educação Ambiental [4], entende-se que esta venha a ser: "[...] uma dimensão da educação", sendo "[...] atividade intencional da prática social, que deve imprimir ao desenvolvimento individual um caráter social em sua relação com a natureza e com os outros seres humanos". Logo: "[...] toda ação educativa deve ser direcionada para a construção da igualdade e promoção das diversidades para que possamos satisfazer nossas necessidades sem opressão, discriminação e reprodução da dominação e dos mecanismos de expropriação" [6].

Essa perspectiva evidencia a atuação do processo de globalização, homogeneizando o conhecimento e os saberes e fazeres que são parte de pequenos grupos e comunidades específicas. Nesse sentido, a educação ambiental representa um importante papel na transmissão e preservação do que é tradicional, tornando-se um espaço de voz para as comunidades e permitindo a exposição de seus anseios e necessidades.

A educação ambiental deve ser traduzida para a atualidade dos sujeitos da ação educativa envolvidos, como potencializadora da interação entre sujeitos, sendo oposta aos sistemas de instrução baseadas no ensino como mera transferência de conteúdo, valorizando a realidade concreta de cada comunidade, nos sujeitos com seus saberes, fazeres, perspectivas e modos de resistência. Diante disso, deve-se compreender as particularidades de cada comunidade, permitindo que seja proposta uma relação entre o ambiente e a sociedade a partir da perspectiva local, enfocando a cultura como processo de conformação de relações sociais e as atividades tradicionais comunitárias, bem como, as escalas político-econômicas.

Deve-se então, considerar que os saberes e fazeres advindos por meio dos indivíduos e da coletividade tornam- se fundamentais para o ato da emancipação pessoal e coletiva, bem como, na construção da identidade coletiva e conscientização crítica em relação ao mundo. A educação ambiental deve "[...] contribuir para a formação de cidadãos conscientes, aptos a decidir e atuar na realidade socioambiental de um modo comprometido com a vida, com o bem-estar de cada um e da sociedade, local e global [3]. Para tanto, os diálogos firmados devem partir do (re)pensar das "educações ambientais" praticadas em seu contexto cotidiano, tornando-se necessário compreendermos as formas mais apropriadas de transmissão, mediação e potencialização do sentimento de valorização da cultura, autonomia social e defesa da territorialidade de cada comunidade, garantindo a educação pela significação dos conteúdos curriculares.

Quando entendemos a realidade de cada aluno, passamos a compreender que avaliar não é examinar ou medir, mas acompanhar a construção da aprendizagem. E mesmo que cada aluno faça parte de uma construção coletiva, cada sujeito apresenta especificidades e características distintas. Quando avaliamos sob tal contexto, proporcionamos ao aluno, refletir sobre cada questão e com isso estimulamos a emancipação desse aluno, e consequentemente, sua autonomia.

Esse processo avaliativo é denominado por Hoffmann

[9] como avaliação mediadora, encaminhando-se como um momento investigativo e reflexivo sobre o resultado de cada aluno. Nesta perspectiva, o professor não pode se limitar a apenas transferir conhecimento e corrigir respostas certas ou erradas, mas deve incentivar o diálogo, estimular questionamentos e formular desafios, favorecendo a descoberta de melhores soluções para um determinado conteúdo ou questão. Devemos entender que avaliar é um processo singular. Cada aluno é diferente e aprende de um jeito diferente.

Portanto, temos a necessidade de um planejamento e acompanhamento mais detalhado em relação ao rendimento escolar dos alunos, para que o professor consiga readequar seus métodos avaliativos, exige uma postura que o condicione a prestar mais atenção no comportamento dos alunos, bem como conhecê-los, ou seja, não avaliando apenas erros e acertos, mas também, questões socioemocionais, que influenciam diretamente no processo de ensino e aprendizagem.

Segundo Hoffmann [10], todo processo avaliativo deve ter por intenção: observar o aluno; analisar e compreender as estratégias de aprendizagem e; tomar decisões pedagógicas que sejam favoráveis à continuação do processo. Corroborando com esse pensamento, Luckesi [7] diz que as avaliações apresentam três funções, a saber: diagnóstica, formativa e somativa.

Ao utilizarmos as tecnologias digitais, principalmente no contexto avaliativo, torna-se necessário que os professores sejam peças-chaves e promovam o deslocamento destas ferramentas das margens da educação para seu centro, apresentando aos alunos um caminho claro para melhorar a eficiência educacional. A sociedade moderna passa por mudanças cada vez mais impactantes e velozes, sejam elas sociais, políticas, econômicas ou culturais. Sendo assim, educação e tecnologias não podem estar dissociadas.

Por meio das tecnologias digitais, é possível potencializar a aprendizagem em seus diversos espaços de aprendizagem, transformando a forma de se oferecer educação. Neste cenário, o professor é o principal ator desse contexto de transformação social e educacional, onde terá que lidar no cotidiano das aulas, tornando seu uso, inteligente e criativo. Dessa forma, professor e aluno devem estar em sintonia para que essas tecnologias possam ser utilizadas de maneira ética e didática, provocando uma troca dos saberes. Portanto, é possível expandir a capacidade pela busca por conhecimento, compartilhar materiais de estudos, provocar debates sobre temas propostos e também propor momentos avaliativos.

É preciso reconhecer as tecnologias digitais como parte da vida dos alunos, fazendo uso deste também como recurso didático, diminuindo o distanciamento entre a escola e o cotidiano. Devemos considerar, que "[...] é indiscutível a necessidade crescente" [3] do uso das tecnologias digitais "[...] como instrumento de aprendizagem escolar" para que os alunos possam estar atualizados "[...] e se instrumentalizarem para as demandas sociais presentes e futuras" [3]. E consequentemente, potencializar a construção do conhecimento por meio da troca de experiências, dos aprendizados e do acesso mais amplo às informações.

Dentro desse contexto, a formação continuada de professores torna-se um importante mecanismo no processo educacional, uma vez que, permite ao professor identificar suas dificuldades no fazer docente, buscando maneiras de contornar tais problemas por meio da descoberta de novos conhecimentos e ferramentas que possam facilitar e inovar a práxis cotidiana. Segundo Tardif [14], "a inovação, o olhar crítico e a teoria são ingredientes essenciais da formação de um prático reflexivo, capaz de analisar situações de ensino e as reações dos alunos, como também as suas, e capaz de modificar, ao mesmo tempo, seu comportamento e os elementos da situação, a fim de alcançar os objetivos e ideais por ele fixados" [14].

Assim, a formação continuada pode ser considerada como um momento de reconstrução e modificação da prática docente, mas sobretudo, um processo que objetiva a troca de experiência e a reflexão, com a finalidade de impactar os resultados profissionais dos professores e consequentemente, serem agentes de transformação na vida de cada aluno. Segundo Nóvoa [2], "[...] o aprender contínuo é essencial e se concentra em dois pilares: a própria pessoa, como agente, e a escola como lugar de crescimento profissional permanente".

Ao propor um olhar reflexivo sobre a prática, o professor busca conhecer a realidade na qual está inserido, as formas de intervir, as relações dos saberes teóricos e práticos. Ao propor essa postura, inicia-se uma condição de pesquisador, qualificando o ensinar e o aprender. Na abordagem reflexiva a aprendizagem com a própria experiência é elemento indispensável no desenvolvimento do conhecimento sobre ensino. O papel do professor no cenário educacional deve ser estimulante e provocante, criando alternativas que possam condicionar os alunos nas suas possibilidades de aprendizagem, na análise dos dados, nas evidências e informações coletadas e produzidas sobre determinado assunto, construindo assim, um conhecimento teórico, prático e científico.

Dessa maneira, torna-se necessário conduzir o processo da prática reflexiva para ser um mecanismo de transformação e emancipação da educação. De acordo com Freire [15], "[...] uma pedagogia da autonomia tem de estar centrada em experiências estimuladoras da decisão e da responsabilidade, vale dizer, em experiências respeitosas de liberdade", libertando-nos de nossas condições atuais por meio de pensamentos humanizados e pautados na realidade na qual estamos inseridos.

III. Percurso Metodológico

A pesquisa é de natureza qualitativa, onde segundo Lüdke e André [12] "[...] os focos de observação são determinados basicamente pelos propósitos específicos de estudo, que por sua vez derivam de um quadro teórico geral, traçado pelo pesquisador". A pesquisa também seguiu o campo do tipo exploratória descritiva, utilizando como técnicas de coleta de dados a observação participante, onde "[...] o pesquisador entra em contato com a comunidade, grupo ou realidade estudada" [13], a aplicação de questionários, entrevistas, rodas de conversa, análise documental e relatos.

Nesse sentido, a pesquisa foi realizada com educadores atuantes no município de Linhares, município localizado no estado do Espírito Santo - Brasil, que podem ser compreendidos como professores (de qualquer disciplina, modalidade ou etapa de ensino), gestores e agentes comunitários. Esses educadores são cursistas dos cursos de "Especialização em Educação Ambiental" e de "Aperfeiçoamento em Metodologias de Educação Ambiental", no âmbito do Projeto Rio Doce Escolar.

A pesquisa está guiada pela oferta de uma formação de professores por meio de um curso *on-line* aberto e massivo, popularmente conhecido como MOOC, que é um acrônimo para *Massive Open On-line Course*. Por ser uma modalidade de educação *on-line*, possibilita a oferta de cursos gratuitos para diversos segmentos e públicos. Esse formato permite apresentar um determinado conteúdo de forma mais abrangente e democrática.

Para a realização desta etapa, utilizamos o modelo ADDIEM (*Analysis*, *Design*, *Development*, *Implement*, *Evaluate* e MOOC), conforme demonstrado na "Fig. 1", sendo um modelo pautado na elaboração de cursos MOOC`s,, que visa criar experiências no contexto do design instrucional, que "[...] se dedica a planejar, preparar, projetar, produzir e publicar textos, imagens, gráficos, sons e movimentos, simulações, atividades e tarefas ancorados em suportes virtuais" [1], com o objetivo de melhorar os processos de aprendizado, no qual cada fase e resultados subsidiam os próximos passos de forma integrada.

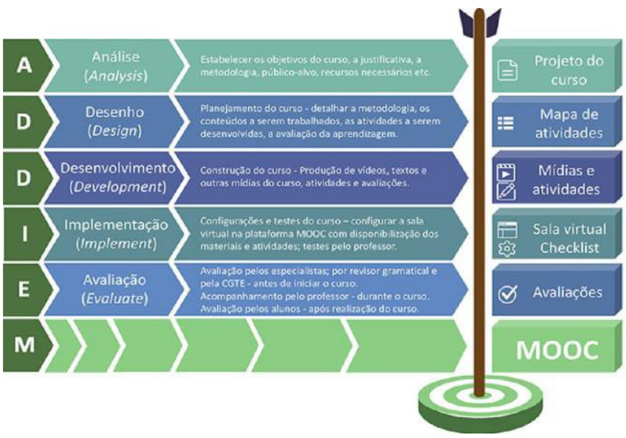


Fig. 1. Modelo ADDIEM [16]

A pesquisa utilizou como técnicas de coleta de dados a observação participante, a aplicação de questionários e a análise documental e de relatos. Salientamos, que mesmo a pesquisa sendo de cunho qualitativo, dados quantitativos também são importantes no processo de análise e discussão dos resultados. Aliado aos instrumentos de coleta de dados, utilizamos os registros dos fóruns e atividades previstas na organização do MOOC, considerando elementos que podem conferir significação para o pesquisador e sujeitos da pesquisa.

Os dados obtidos foram tratados por meio da análise de conteúdo à luz dos pressupostos de Bardin [11] de maneira "[...] a serem significativos e válidos". Quando analisamos dados fiéis, podemos propor inferências e adiantar interpretações a propósitos dos objetivos previstos ou que digam respeito a outras descobertas inesperadas.

Nesse sentido, buscamos criar um modelo de categoria de análise de conteúdo que permitam compreender os processos avaliativos realizados pelos educadores, doravante, sujeitos da pesquisa, considerando as perspectivas pedagógicas no âmbito teórico e prático. Portanto, ao criarmos o processo de codificação, foi preciso definir os seguintes itens:

- Categorias: estão de acordo com o tema da pesquisa, baseando-se nas concepções teóricas e práticas sobre avaliação da aprendizagem, tecnologia digital e educação ambiental.

- Subcategorias: estão pautadas nos objetivos da pesquisa, com foco nas intencionalidades pedagógicas dos atos avaliativos, considerando dois cenários de análise: o fazer tradicional e a intencionalidade emancipatória.

- Unidades de registro: foram baseadas de acordo com as subcategorias, tendo seus parâmetros oriundos do referencial teórico que embasa a pesquisa.

- Regras de contagem: foi utilizada a técnica da presença ou ausência, baseada na frequência simples de incidências. A contagem das incidências também será convertida em dados percentuais.

TABELA I. CATEGORIA DE ANÁLISE DE CONTEÚDO: AVALIAÇÃO DA APRENDIZAGEM

Subcategorias	Unidades de Registro
Aproximação do fazer tradicional	Modelo avaliativo com foco no conteúdo
	Modelo avaliativo padronizado
	Modelo avaliativo de caráter quantitativo
	Modelo avaliativo centrado no professor
	Modelo avaliativo constatativo
	Modelo avaliativo sentencivo
Aproximação da intencionalidade emancipatória	Avaliação com foco na aprendizagem
	Modelo avaliativo personalizado
	Modelo avaliativo de caráter qualitativo
	Modelo avaliativo que potencializa a autonomia do aluno
	Modelo avaliativo mediador
	Modelo avaliativo reflexivo

Como resultado do processo de codificação e de acordo com a "Tabela I", ficou definido a seguinte estrutura: uma categoria de análise de conteúdo: concepções sobre avaliação da aprendizagem. A categoria foi dividida em duas subcategorias (ou eixos): aproximação do fazer tradicional e aproximação da intencionalidade emancipatória. E cada subcategoria teve 6 (seis) unidades de registro como parâmetro de análise.

A estrutura da categoria de análise foi elaborada de acordo com perspectivas que corroboram com a integração do fazer tradicional aliado à inserção de novos ambientes/conhecimentos por meio de uma intencionalidade emancipatória, considerando os processos avaliativos, apoiado pelo uso de tecnologias digitais e tendo como base os conteúdos referentes a Educação Ambiental.

O estudo obteve aprovação do Comitê de Ética em Pesquisa (CEP), sob o parecer de número 5.980.615. Além disso, todo material didático, produções técnicas e trâmites pedagógicos e burocráticos, foram validadas pelo Grupo de Pesquisa "Inovação e Criatividade na Educação" (INOCRIE), vinculado ao Instituto Federal do Espírito.

IV. ANÁLISE E RESULTADOS

Os primeiros resultados obtidos são provenientes da aplicação de um MOOC para os cursistas dos cursos de "Especialização em Educação Ambiental" e de "Aperfeiçoamento em Metodologias de Educação Ambiental", no âmbito do Projeto Rio Doce Escolar. No MOOC intitulado de "Avaliação da Aprendizagem no Contexto da Educação Ambiental" [2] foi disponibilizado conteúdos que visam instrumentalizar os cursistas em relação às formas de avaliar, considerando diferentes perspectivas, além de promover o uso das tecnologias digitais como apoio aos processos avaliativos, tendo como base os conteúdos referentes a Educação Ambiental.

No ambiente virtual, o curso está dividido em três módulos: I. Avaliação da aprendizagem; II. Uso de tecnologias digitais; e III. Avaliação no contexto da educação ambiental. Além disso, os módulos estão organizados em três sessões: para aprender; aprender fazendo; e para ir além. O curso tem carga horária total de 20 horas.

A priori, tivemos como sujeitos participantes, os educadores atuantes no município de Linhares, entre professores (de qualquer disciplina, modalidade ou etapa de ensino), gestores e agentes comunitários. Portanto, o questionário envolveu perguntas relacionadas com o dia a dia desses educadores, de acordo com os temas disponíveis nos módulos. Tivemos um total de 92 (noventa e dois) matrículas no MOOC, mas apenas 71 (setenta e um) participantes que se propuseram a realizar parcialmente ou em sua totalidade as atividades propostas.

Entre os principais dados, 62,1% dos participantes apresentou entre 7 a 25 anos de experiência profissional; 45,5% dos educadores possuem uma carga horária semanal de 30h até 40h; 75,8% são formados a nível de pós- graduação; 42,4% dos educadores atuam em escolas de ensino fundamental; apenas 27,3% utilizam alguma tecnologia digital nos processos avaliativos; 77,3% nunca realizaram formação específica sobre educação ambiental; 40,9% nunca realizaram formação específica sobre tecnologias digitais e; 42,4% apontam o conhecimento limitado em tecnologia como principal fator de dificuldade.

[2] https://mooc.cefor.ifes.edu.br/

Durante a realização do MOOC, os educadores participantes tiverem contato com diversas atividades, das quais selecionamos como fonte para a análise de conteúdo, o fórum de discussão intitulado “Como você avalia seu aluno?”, disponibilizado no módulo sobre avaliação da aprendizagem, e a atividade “Compartilhando experiências”, no formato base de dados, sendo uma das atividades práticas do módulo sobre avaliação no contexto da educação ambiental.

Sendo assim, iniciamos o processo de análise de conteúdo por meio dos registros do fórum de discussão, no qual apresentou a seguinte questão aos cursistas: “como processo de reflexão e de compartilhamento de experiências, com um breve relato, conte-nos como você avalia seus alunos”. O uso desse recurso teve o intuito de promover debates e ampliar reflexões acerca do tema sobre avaliação da aprendizagem, sendo ponto de partida para os demais conteúdos teóricos e práticos da formação.

Ao todo, tivemos um total de 149 (cento e quarenta e nove) interações, das quais foram analisadas a luz dos pressupostos de Bardin [11], tendo como base a categoria de análise de conteúdo referente as concepções sobre modelos da avaliação formativa. A organização da análise de conteúdo foi descrita na sessão dedicada ao percurso metodológico. Os dados obtidos, evidenciam um cenário que era previsto, considerando os resultados da tabulação e análise do questionário diagnóstico. Das interações realizadas no fórum de discussão, 77% representam uma aproximação do fazer tradicional no momento de avaliar o aluno, contra 26% que demonstram uma aproximação da intencionalidade emancipatória.

Nesse sentido, os resultados das unidades de registros trazem uma melhor compreensão de cada subcategoria. Em relação a aproximação do fazer tradicional, tivemos os seguintes resultados: 79% das interações indicaram a preferência pelo uso de um modelo avaliativo com foco no conteúdo; 89% dos educadores utilizam modelos padronizados de avaliação; 77% priorizam as avaliações de caráter quantitativo; 64% elaboram suas avaliações pautadas nos interesses do professor; 77% utilizam modelos avaliativos constatativos; e 77% têm preferência por avaliações que são sentencivas.

As unidades de registros da subcategoria “aproximação da intencionalidade emancipatória” trazem o seguinte resultado: 37% dos educadores dizem utilizar um modelo avaliativo que tenha foco na aprendizagem do aluno; 13% indicaram que elaboram avaliações personalizadas; 37% priorizam as avaliações de caráter qualitativo; 15% buscam potencializar a autonomia do aluno nos momentos avaliativos; 21% buscam utilizar modelos avaliativos que sejam mediador do processo de ensino e aprendizagem; e 31% utilizam modelos avaliativos que promovam a reflexão dos alunos.

Em relação as concepções sobre modelos de avaliação formativa, é possível constatar uma predominância de atitudes que rementem a um processo tradicional em relação as práticas dos atos avaliativos. A maioria das interações destacaram o uso de modelos avaliativos nos quais o professor tenha a sensação de maior domínio dos resultados, como avaliações padronizadas, de caráter quantitativo e que permitam constatar e classificar os alunos.

Outro dado importante, é em relação ao uso das tecnologias digitais. Das 149 (cento e quarenta e nove) interações realizadas no fórum de discussão, temos apenas um apontamento para seu uso como recurso mediador dos processos avaliativos. Essa informação deve vir acompanhada de uma reflexão mais aprofundada em relação a dissociação existente entre discurso e prática no contexto educacional, considerando que no questionário diagnóstico 65,2% dos educadores consideraram o uso de tecnologias digitais uma contribuição importante nos processos avaliativos e um percentual considerável indicou fazer uso de várias dessas tecnologias no momento de avaliar seus alunos.

Sobre o uso de modelos avaliativos que demonstraram uma aproximação da intencionalidade emancipatória, as interações destacaram a preferência dos educadores por atividades de caráter qualitativo, com foco na aprendizagem do aluno e na mediação e reflexão do processo de ensino e aprendizagem, remetendo a uma ação educativa “[...] com base na busca de alternativas de integração aluno-escola, com vistas a que, mediante questões desafiadoras, o educando desenvolva a sua autonomia nos diversos campos de sua formação, seja este moral, afetivo, intelectual ou social” [12].

É importante reconhecer o esforço dos educadores que buscam (re)significar os processos avaliativos, muitas vezes na contramão das diretrizes curriculares, dos tramites burocráticos e da precarização da infraestrutura oferecida pelas escolas, fazendo da avaliação um “[...] instrumento do reconhecimento dos caminhos percorridos e da identificação dos caminhos a serem perseguidos” [8].

Portanto, destacamos a importância dos dados apresentados terem elucidado uma realidade que necessita de propostas e intervenções que favoreçam uma educação problematizadora, transformadora, crítica e dialógica, sendo justamente o modelo de formação que é proposto no MOOC “Avaliação da Aprendizagem no Contexto da Educação Ambiental”, no qual busca orientar e instrumentalizar os educadores frente aos processos avaliativos e sobretudo, considerando as diferentes perspectivas e cenários envolvidos e sabendo que as formas de aprender são singulares e multidimensionais.

Na atividade “Compartilhando experiências” foi o momento de colocar em prática o que foi aprendido durante o curso. Nesse sentido, compartilhamos um modelo de plano de aula pautado nos três momentos pedagógicos propostos por Muenchen e Delizoicov [8]), no qual era possível criar um plano de aula ou adaptar algum plano que já tenha sido realizado ou visto em algum outro local. Direcionamos a atividade para ser o momento do cursista colocar em prática o que foi aprendido durante o curso, possibilitando relacionar diferentes conteúdos e desenvolver novos saberes e fazeres docentes.

Ao enviar o plano de aula, o cursista tinha acesso as postagens dos demais participantes, podendo comentar e/ou colaborar. No total, tivemos 63 (sessenta e três) planos postados, que também foram analisados a luz dos pressupostos de Bardin [11] e de acordo com a categoria de análise já mencionada. Sendo uma atividade de encerramento da formação, os resultados da análise de conteúdo trouxeram diferente resultados, mas satisfatórios em relação aos objetivos propostos.

Na análise de conteúdo dos planos de aula, tivemos o seguinte resultado: 79% dos planos de aula demonstraram uma aproximação da intencionalidade emancipatória em relação as atividades e recursos propostos. Os outros 21% apresentaram dificuldades na articulação dos momentos avaliativos e o uso de tecnologias digitais.

Principalmente, em aulas que envolvem conteúdos sobre educação ambiental, é fundamental que se tenha momentos avaliativos de diagnóstico. O saber intrínseco de cada aluno é importante na construção da significação dos conteúdos propostos e na organização do processo avaliativo de caráter formativo.

Todavia, tivemos avanços em relação aos modelos avaliativos utilizados: 62% buscaram utilizar modelos avaliativos com foco na aprendizagem do aluno, 62% priorizaram os momentos avaliativos de caráter qualitativo e mais de 60% também utilizaram avaliativos mediadores e reflexivos, contribuindo diretamente na formação da autonomia dos alunos diante de possíveis dificuldades e numa formação que potencialize o sendo crítico e atuante frente as responsabilidades individuais e coletivas que envolvem a problemática sobre questões ambientais.

O MOOC ofertado mostrou-se estar alinhado com o objetivo proposto, possibilitando aos cursistas: Compreender a avaliação da aprendizagem quanto às diferentes abordagens, sendo campo de investigação e reconstrução de práticas docentes e discentes; Ampliar o domínio de concepções e processos avaliativos de acordo com os parâmetros estabelecidos pela BNCC, sobretudo no que tange o contexto da educação ambiental; Desenvolver competências para a elaboração de diferentes instrumentos e práticas de avaliação por meio do uso das tecnologias digitais; e Propiciar diálogos e reflexões sobre avaliação da aprendizagem no contexto da educação ambiental.

Ao final das análises e resultados, nota-se que o curso cumpriu seu propósito de propiciar a construção de conhecimentos e habilidades necessárias à elaboração e aplicação de propostas educacionais inovadoras no contexto da avaliação da aprendizagem, pensando os pilares que envolvem a educação ambiental e fazendo uso de tecnologias digitais.

V. Considerações Finais

Avaliar sob a perspectiva de que os aspectos qualitativos prevaleçam sobre os quantitativos já é determinado pela Lei de Diretrizes e Bases da Educação (LDB). Todavia, na prática, ainda vemos um processo explicitamente classificatório e consequentemente, excludente. Costumeiramente, o modelo que vem pautando a base educacional é o de notas, que exacerba a competitividade entre os alunos e não valoriza a multiplicidade dimensional da aprendizagem.

É imprescindível que aconteçam mudanças não apenas nos projetos educacionais, mas também em questões sociais e culturais. Os resultados dos processos avaliativos precisam estar pautados na cooperação e inclusão, não valorizando apenas notas, mas toda conquista do aluno. Dentro dessa perspectiva, é essencial que o professor conheça cada aluno e suas necessidades.

Entretanto, para que os professores tenham condições de organizar suas aulas e métodos avaliativos, pautados não só nos conteúdos curriculares, mas também em situações que perpassam o ambiente da sala de aula, torna-se necessário estarem atualizados e suficientemente preparados para a aplicação de metodologias inovadoras e atuações em diferentes espaços, na qual o aluno é o centro do processo de ensino e aprendizagem.

Para tanto, novos processos educativos precisam ser considerados como vias de construção e de transformação, propondo estratégias, intervenções e tarefas que possibilitem o desenvolvimento de habilidades e de comportamentos tais como, aprender a aprender, criar e empreender, gerenciar informações, derivar dos resultados de pesquisa novas possibilidades de aplicações no âmbito da atuação profissional, modificar padrões estabelecidos e identificar diferentes possibilidades de atuação social, dentre outros.

Reiteramos assim, a importância de novos estudos que aprofundem as nuances que envolvem a avaliação escolar e o uso das tecnologias digitais, principalmente no contexto da educação ambiental, bem como do planejamento e acompanhamento das ações educativas, dos instrumentos a serem utilizados nos processos avaliativos, da análise dos resultados e das diferentes concepções da avaliação diante de suas manifestações teóricas e práticas.

Agradecimentos

O presente trabalho foi realizado com o aporte financeiro da Fundação Renova, a partir de um convênio entre IFES, FACTO e Fundação RENOVA- Processo IFES nº23187.001719/2021-93.

Referências

[1] A. Filatro e S. Piconez, Design instrucional contextualizado, Congresso internacional de educação a distância, 11rd ed., Salvador, 2004.

[2] A. Nóvoa, Os professores e a sua formação, Lisboa: Quixote, 1992.

[3] Brasil, Parâmetros curriculares nacionais: introdução aos parâmetros curriculares nacionais, Brasília: MEC/SEF, 1998.

[4] Brasil, "Diretrizes curriculares nacionais para educação ambiental". Brasília: MEC/SEF, 2012.

[5] C. F. Loureuro, Educação ambiental e gestão participativa na explicitação e resolução de problemas, Revista gestão em ação, 2008.

[6] C. Luckesi, Avaliação da aprendizagem escolar: estudos e preposições, 1rd ed., São Paulo: Cortez, 2013.

[7] C. Luckesi, Avaliação da aprendizagem: componente do ato pedagógico, São Paulo: Cortez, 2011.

[8] C. Muenchen e D. Delizoicov, Os três momentos pedagógicos e o contexto de produção do livro "Física", Revista ciência e educação, São Paulo, 2014.

[9] J. Hoffmann, Avaliação: mito e desafio: uma perspectiva construtitvista, 35rd ed., Porto Alegre: Mediação, 2005.

[10] J. Hoffmann, Avaliação mediadora: uma prática em construção na pré-escola à universidade, Porto Alefre: Mediação, 2009.

[11] L. Bardin, Análise de conteúdo, Lisboa: Edições 70, 2011.

[12] M. Ludke e M. André, Pesquisa em educação: abordagens qualitativas, 2rd ed., São Paulo: EPU, 2013.

[13] M. Marconi e E. Lakatos, Metodologia científica, 6rd ed., São Paulo: Atlas, 2011.

[14] M. Tardiff, Saberes docentes e formação profissional, Petrópolis: Vozes, 2002.

[15] P. Freire, Pedagogia da autonomia, Rio de Janeiro: Paz e Terra, 1996.

[16] V. Battestin e P. Santos, ADDIEM – um processo para criação de cursos MOOC, Revista EaD em foco, Rio de Janeiro, 2022.

USO DE MICRO MUNDOS EN EL APRENDIZAJE DE CONCEPTOS BÁSICOS DE PROGRAMACIÓN, PARA FUTUROS PROFESORES DE EDUCACIÓN INFANTIL

Sergio Cavero
Departemento de Informática y Estadística
Universidad Rey Juan Carlos
Móstoles, España
sergio.cavero@urjc.es

Liliana Patricia Santacruz Valencia
Departemento de Informática y Estadística
Universidad Rey Juan Carlos
Móstoles, España
liliana.santacruz@urjc.es

***Resumen*—Hoy en día, existe un amplio abanico de herramientas diseñadas para enseñar habilidades de programación, cuya efectividad ha sido verificada, según recoge la literatura actual. En esta línea, este artículo presenta un estudio de caso realizado a través de 8 clases de 90 minutos de duración, para enseñar conceptos básicos de programación (variables, secuencias, bucles y condicionales), a estudiantes (N= 52) de primer año de Educación Infantil, quienes en un futuro podrán enseñar a sus estudiantes habilidades de programación. Para ello, se han utilizado las herramientas Code.org, ScratchJr y CoSpaces, con las que los estudiantes se han familiarizado previamente, revisando su usabilidad, aprendiendo los comandos de programación utilizados en cada una de ellas y alcanzando una comprensión conceptual de la codificación. Además, se ha comprobado si los estudiantes son capaces de utilizar correctamente los bloques de programación y mejorar su habilidad para explicar verbalmente qué es programar. También, se ha constatado que, el atractivo de las herramientas, es decir, la interfaz de usuario y su diseño, está significativamente relacionado con el aprendizaje de la programación informática por parte de los futuros profesores.**

Palabras clave — programación, código, educación preescolar

I. INTRODUCCIÓN

Como ya anotaba Papert [1], el ordenador trajo una nueva forma de aprender, siendo la programación informática una de ellas. De ahí que LOGO ofreciera, por una parte, un lenguaje de programación fácil, con un conjunto de instrucciones sencillas que retaban intelectualmente a los estudiantes a crear programas para resolver tareas, así, los niños podían llevar a cabo procesos cognitivos, reflexionar sobre sus errores y utilizar su experiencia para crear nuevos programas mejorados, y por otra, un entorno en el cual poner en práctica el pensamiento Piagetiano acerca de que los niños no son recipientes vacíos para ser llenados con conocimiento, sino constructores activos de conocimiento que están creando y probando constantemente sus propias teorías del mundo [2].

Hace casi diez años que en España se empezó a formar un movimiento que ya había tenido lugar en países como Reino Unido, Francia o Estonia, a favor de la enseñanza de la programación informática en Educación Primaria y también a edades tempranas [3], como una herramienta que facilita la adquisición de competencias transversales relacionadas con la resolución de problemas, el pensamiento analítico, el trabajo en equipo o la creatividad.

A. Importancia de la Programación Informática

Programar requiere planificar, utilizar un lenguaje de programación, plantear hipótesis y probarlas, establecer secuencias que favorezcan el logro de los objetivos y depurar errores. Es decir, se dan al ordenador instrucciones específicas para resolver un problema concreto y, quien lleva a cabo esta labor experimenta cambios en el pensamiento que, le permiten realizar otras tareas que implican procesos afines como la resolución de problemas [4].

Aunque la introducción de la programación informática en el contexto educativo es una realidad, en parte gracias a la implantación de iniciativas que promueven el desarrollo de la competencia digital [5], [6], muchos estudios muestran su integración a nivel curricular en la etapa de Educación Secundaria, sin alcanzar una verdadera implantación a nivel de Educación Infantil y Educación Primaria [7].

Es por ello por lo que, la formación del profesorado es una de las principales vías a través de la cual se puede conseguir una integración total de la programación informática en el aula a diferentes niveles, eliminando una barrera importante que les impide impartirla: su falta de formación [8].

Atendiendo a esta necesidad de formación, la asignatura "Informática y Competencia Digital Docente", que se imparte a los estudiantes de primer año del Grado en Educación Infantil de la Universidad Rey Juan Carlos, se encuadra en un itinerario formativo basado en el Marco Común de Competencia Digital Docente [9], el cual contempla un área competencial denominada "Creación de Contenidos Digitales" en la que se trabaja la programación informática.

Con el ánimo de promover la enseñanza de la programación informática entre los estudiantes de dicha asignatura quienes serán futuros profesores, se ha llevado a cabo un estudio de caso en el que han participado 52 estudiantes, los cuales han interactuado durante su proceso de enseñanza y aprendizaje con herramientas de programación por bloques como: *(i)* Code.org, una plataforma educativa orientada a estudiantes de todas las edades y que ofrece cursos gratuitos para aprender programación; *(ii)* ScratchJr., una aplicación gratuita para dispositivos móviles que permite a los niños crear sus propias historias o juegos interactivos y *(iii)* CoSpaces, una plataforma parcialmente gratuita para crear y compartir mundos virtuales e interactivos.

B. Factores condicionantes del aprendizaje

En el presente estudio se han tenido en cuenta muchos factores que podían influir en los resultados como: *(i)* el uso de las aplicaciones, ya que puede afectar de diferente forma a los participantes, puesto que las habilidades cognitivas individuales son distintas, así como también la motivación y/o las emociones, pueden influir en cómo de bien son capaces de comprender y aprender de forma individual; *(ii)* el desempeño en las tareas de razonamiento espacial y rotación mental a través de las cuales el estudiante desarrolla su capacidad de poder manipular mentalmente la posición de objetos, tras representarlos tridimensionalmente en su cabeza; *(iii)* la afinidad o el gusto por la aplicación en sí, puede afectar la comprensión del contenido, ya que, cuanto más gusta una aplicación, por ejemplo, por los personajes que aparecen en ella, esto conduce a una mayor motivación e interés en la misma. Pero, hay que tener en cuenta que, lo que se busca es que aparte de estar motivados, presten más atención al contenido educativo y sean capaces de comprenderlo.

C. Hipótesis y preguntas de investigación

El presente estudio de caso busca: *(i)* que los estudiantes mejoren la comprensión de los conceptos básicos de programación y *(ii)* mostrar que las herramientas elegidas pueden ser utilizadas para dicho propósito, proporcionando, además, escalas cualitativas.

En primer lugar, se puede predecir que, la Hipótesis H es:

H: Los futuros profesores aprenderán los conceptos básicos de programación a través de la participación en las actividades propuestas durante las 8 clases en las que inicialmente se les explicarán los conceptos teóricos, los cuales podrán poner en práctica de forma guiada, mediante el uso de las aplicaciones Code.org, ScratchJr. y CoSpaces.

Para que tenga lugar la transferencia de aprendizaje en las nuevas situaciones es necesario que los estudiantes tengan claro el objetivo de aprendizaje y que desarrollen un esquema acerca de los conceptos que pueden aplicar a las mismas. Así, al interactuar con tres herramientas diferentes, es posible que los estudiantes desarrollen un entendimiento amplio de lo que es la programación y cómo puede utilizarse en diferentes contextos (por ejemplo, como complemento para la unidad didáctica diseñada para el proyecto final de la asignatura).

Por tanto, en este estudio de caso, se explora si los estudiantes adquieren una comprensión conceptual de lo que es la programación informática.

La primera pregunta de investigación es:

RQ1: ¿Pueden los estudiantes adquirir una comprensión conceptual de lo que es la programación informática mediante la participación en las actividades propuestas a través de 8 clases de 90 minutos, utilizando Code.org, ScratchJr y CoSpaces?

Considerando la motivación de los estudiantes por aprender y utilizando las aplicaciones propuestas, se plantean las siguientes preguntas de investigación:

RQ2: ¿Puede el uso de metáforas entre el mundo real y el mundo de la programación informática mejorar el aprendizaje de conceptos básicos de programación informática?

RQ3: ¿Puede la motivación condicionar el aprendizaje de conceptos básicos de programación informática a través de las aplicaciones propuestas?

Y finalmente, se plantea una pregunta de investigación para saber si tras el uso de las diferentes aplicaciones, los estudiantes son capaces de generar sus propias creaciones.

RQ4: ¿Puede el uso de Code.org, ScratchJr y CoSpaces ser de utilidad para enseñar a los estudiantes a crear juegos de realidad virtual (RV), mediante CoSpaces?

El artículo se estructura de la siguiente manera: *Sección II Contexto*, describe el marco y trabajos relacionados en formación de profesores en programación informática. *Sección III: Metodología*, explica la construcción del estudio de caso. *Sección IV: Resultados*, analiza los hallazgos obtenidos. *Sección V: Discusión*, reflexiona sobre el uso de herramientas tecnológicas para mejorar motivación y aprendizaje de programación en futuros profesores. *Sección VI: Conclusiones*, aborda las preguntas de investigación y expone las conclusiones del trabajo.

II. Contexto de Investigación

A continuación, se describe el contexto dentro del cual se enmarca el presente trabajo.

D. Dificultades para incorporar la enseñanza de la programación informática en el aula

A pesar del creciente interés en fomentar la enseñanza de la programación informática, aún existen algunas dificultades que ralentizan su integración en el aula, como la falta de una didáctica estándar [10], la escasez de profesores capacitados para enseñar contenidos propios de esta disciplina o los pocos recursos disponibles en algunos centros educativos [11]. A esto hay que sumarle que, la programación informática solo se ha considerado como herramienta educativa en Educación Secundaria, donde su impartición con frecuencia es optativa, a diferencia de Educación Primaria donde es obligatoria. Y en general, no se le reconoce el carácter académico riguroso y la proyección profesional que ofrece a quien la conoce y pone en práctica. Es, por tanto, un tema de vital importancia que ha llamado la atención de muchos autores que se refieren al interés que despierta la enseñanza de la programación informática a nivel pre-universitario [12].

No obstante, las nuevas propuestas de lenguajes de programación visual [13], están facilitando poco a poco su integración en las aulas de Educación Infantil y Educación Primaria, para la cual en el Real Decreto 126/2014, de 28 de febrero, se recoge una referencia al uso de las TIC para el desarrollo de la competencia digital o la creación de contenidos. Además, el auge de los juegos de mesa para aprender a programar, las actividades desenchufadas [14] o los kits de robótica [15], [16], favorecen ampliamente dicha labor. Cabe decir que, en España solo algunas comunidades autónomas contemplan la enseñanza de contenidos relativos a la programación informática en los Reales Decretos que ordenan las enseñanzas y el currículo para cada comunidad, y lo hacen de manera distinta para cada una de ellas [16].

E. Hacia la alfabetización computacional

Algunos autores sostienen que escribir facilita la organización del pensamiento para expresar una idea [17]. De igual manera, la programación informática constituye una nueva forma de alfabetización que sirve como medio de expresión [18]. En este punto cabe mencionar que hay autores que consideran que la relación que se suele establecer entre pensamiento computacional y programación informática es inexacta, al afirmar que la programación informática implica un desarrollo del pensamiento computacional [19], puesto que dicho desarrollo estará ligado al tipo de tarea que se pretenda llevar a cabo y la forma en la que ésta se realice. Otros autores afirman que se trata de conceptos en los que intervienen procesos cognitivos similares y que la programación informática hace parte del pensamiento computacional y facilita la comprensión de los elementos que lo conforman, pudiendo utilizarlos dentro del proceso de aprendizaje [20]. Es claro que la relación entre estos conceptos es muy estrecha, pues programar favorece el desarrollo del pensamiento computacional, de la misma manera que el pensamiento computacional contribuye en el aprendizaje de la programación informática [21].

No obstante, si hay algo en lo que todos coinciden es en la dificultad que encarna aprender a programar, debido en parte a que los estudiantes tienen que interpretar y trabajar con conceptos abstractos. Pero, también en parte a la forma incorrecta en la que se enseña [21]. Por ello, a lo largo de los años se han propuesto varias soluciones al problema de la enseñanza de la programación informática [22], entre ellas, el uso de diversas metodologías de enseñanza de la programación, técnicas de aprendizaje activo de inspiración constructivista [23], (como los juegos de rol, narración activa de historias y talleres), lenguajes de programación que se adapten a los programadores novatos [24] y finalmente, los entornos software, dentro de los cuales se distinguen tres tipos: *(i)* los micro mundos que permiten manipular objetos a través de un lenguaje de programación simplificado, *(ii)* las herramientas para la visualización de algoritmos y *(iii)* las herramientas de visualización de programas, integradas, por lo general, en un IDE educativo personalizado, ideales para programadores novatos, pues gracias a las características de visualización, les facilita la comprensión de los conceptos de programación.

F. Contribución

Con el fin de facilitar el aprendizaje de los conceptos básicos de programación informática a los estudiantes (futuros profesores de Educación Infantil), se ha seleccionado el enfoque de entornos software y concretamente la categoría de micro mundos. El proceso de enseñanza se ha llevado a cabo a través de tres fases: conceptualización, práctica y creación. En la fase de "conceptualización", se ha utilizado Code.org para que los estudiantes, a través de la interacción, identificaran ciertos conceptos de programación informática, cuyo significado se ha explicado al final de dicha fase. Durante la segunda fase "práctica", se ha utilizado ScratchJr, con el fin de que los estudiantes pudieran profundizar en el uso de los conceptos de programación vistos en la primera fase y ponerlos en práctica a través de la creación de historias construidas mediante un lenguaje de programación por bloques. Transversalmente, los estudiantes han aprendido a desarrollar su pensamiento, a expresarse y a resolver problemas. Finalmente, en la fase tres, "creación", se ha utilizado CoSpaces, un entorno web de realidad mixta que permite crear escenarios con contenido multimedia interactivo. La selección de CoSpaces responde a que utiliza un lenguaje de programación visual con el que los estudiantes han podido crear programas gráficamente, aliviando en gran medida los problemas relacionados con la sintaxis (estructura del código) y la semántica (significado de los elementos de programación). Además, en este entorno han podido crear una experiencia digital inmersiva, en la que han simulado situaciones del mundo real, es decir han utilizado metáforas y, finalmente, han participado en el aprendizaje basado en problemas, mediante actividades como la creación de una historia y sus diálogos. Los detalles de la experiencia realizada se describen a continuación, en la *Sección III*.

III. METODOLOGÍA

Con el fin de comprobar la efectividad de las herramientas seleccionadas en la enseñanza de conceptos básicos de programación, a los futuros profesores de Educación Infantil, se ha llevado a cabo una evaluación durante cuatro semanas, observando el comportamiento y trabajo realizado por los participantes.

Cabe destacar que en este estudio se ha seguido la metodología de la espiral del pensamiento creativo [25]. En este proceso, los estudiantes han trabajado en sus propios proyectos, aprendiendo sobre el proceso de diseño. Han imaginado y creado un prototipo funcional basado en sus ideas, experimentando con soluciones y compartiendo sus creaciones. A través de la reflexión y la interacción con otros, han generado nuevas ideas y proyectos. Este ciclo continuo de desarrollo les ha permitido aprender a desarrollar sus propias ideas, probar alternativas y obtener retroalimentación. Estos procesos fomentan el desarrollo de competencias como el pensamiento creativo, lógico, comunicación clara y análisis sistemático en la concepción, construcción de proyectos, capacidad de colaboración y una reflexión interactiva.

G. Participantes

La muestra está formada por estudiantes de primer año del Grado en Educación Infantil, que serán futuros profesores. De los 65 estudiantes matriculados en la asignatura, 52 de ellos decidieron participar voluntariamente en el caso de estudio.

H. Los conceptos de programación

El contenido sobre conceptos de programación se ha impartido durante cuatro semanas en 8 sesiones con una duración aproximada de 90 minutos cada una. El esquema de trabajo seguido ha dependido de las actividades a realizar cada día. A continuación, en la Tabla 1, se presentan las tareas realizadas en cada una de dichas sesiones:

TABLA 1 ACTIVIDADES REALIZADAS EN CADA UNA DE LAS SESIONES

Sesión	Actividad
S1	Introducción a los conceptos básicos de la programación mediante Code.org. Evaluación del nivel de conocimiento previo. Primera interacción con CoSpaces explorando los entornos 3D e imágenes 360.
S2	Presentación de los conceptos básicos de programación por medio de metáforas. Primeros pasos con ScratchJr.
S3	Realización de ejercicios con ScratchJr. Repaso de los conceptos por medio de acertijos basados en Wordle.
S4	Presentación de la práctica de ScratchJr que los estudiantes deberán realizar.
S5	Introducción a la RV. Se realizan ejercicios guiados en la plataforma CoSpaces, en concreto, se generan entornos basados en imágenes de 360º.
S6	Realización de ejercicios guiados en la plataforma CoSpaces consistentes en la generación de entornos tridimensionales.
S7	Presentación del proyecto que deberán realizar los estudiantes y clase libre para realizar ejercicios de manera autónoma.
S8	Resolución de dudas, repaso y ejercicios.

I. Medidas

Pre-test. Al comienzo del curso, en la Sesión 1, se ha realizado una prueba para comprobar el conocimiento inicial de los estudiantes sobre la programación informática y las diferentes herramientas existentes para su aprendizaje y también para conocer cuál es su grado de motivación. El cuestionario inicial se ha creado con la herramienta Wooclap, ya que ofrece un entorno más dinámico y atractivo para los estudiantes que un formulario o encuesta tradicional. Las preguntas formuladas fueron las siguientes:

¿Por qué es importante que los niños aprendan a programar?

Entre las respuestas más frecuentes destacan "Con lo que están avanzando las tecnologías es importante para poder seguir el ritmo que lleva la sociedad" o "Porque en un futuro puede ser imprescindible, ya que cada vez utilizamos más las tecnologías en la sociedad".

¿Qué es un programa informático?

De entre los participantes solo dos personas pudieron definir correctamente este término.

¿Qué es un lenguaje de programación?

En este caso, los estudiantes sí que intuían la definición de este concepto y generalmente era definido como "el idioma para programar" o "una forma de comunicarnos con los ordenadores".

Y, por último, se les preguntó, *¿Qué lenguajes de programación conozco?*

La mayoría no conocía ningún lenguaje de programación, pero algunos habían aprendido Scratch en la Educación Secundaria. Se les pidió colaborar en la realización de un listado de herramientas o lenguajes de programación para niños. A partir de esta tarea, se discutió con los estudiantes qué características debe tener una herramienta de programación para niños.

A la vista de los resultados obtenidos, se puede decir que el estudio de caso ha partido con un nivel de conocimiento de los estudiantes, acerca de la programación y las herramientas utilizadas para aprender a programar, bastante deficiente.

Test. Tras las 8 sesiones, se ha realizado una prueba para evaluar el conocimiento de los estudiantes y contrastar el grado de aprendizaje con respecto al inicio de la asignatura. Tanto las preguntas realizadas como los resultados obtenidos se presentan en la *Sección IV*. Para facilitar el análisis de las respuestas, se ha utilizado una escala de Likert con valores como "nada" (0), pasando por una valoración intermedia, "algo" (2), hasta "bastante" (4). Este test fue diseñado con Google Forms, una aplicación para realizar encuestas de ámbito general, e incluye una pregunta abierta para que los estudiantes puedan expresar su opinión general de esta parte de la asignatura.

Caso práctico. Se ha planteado un caso práctico para evaluar el conocimiento adquirido después de las 8 sesiones impartidas, consistentes en desarrollar un programa en ScratchJr para enseñar a los niños las figuras geométricas. Los estudiantes tuvieron un tiempo límite para completar el caso práctico, que fue realizado de forma individual y sin consultar el material de la asignatura.

Para evaluar la correctitud de los programas desarrollados se ha elaborado una rúbrica que cubría cada una de las funcionalidades implementadas. En este caso, se utilizó la siguiente escala: no está hecho (0), hay algo hecho, pero está mal (1), está parcialmente hecho, pero no hay fallos (2) y está bien hecho (3).

Proyecto. La tercera medida para evaluar la correctitud de los programas elaborados ha consistido en una rúbrica que cubría cada una de las funcionalidades del programa diseñado. Este proyecto se ha presentado en la Sesión 7 de la planificación. Este proyecto se ha presentado en la Sesión 7 de la planificación. Dicho proyecto está altamente influenciado por las metodologías de "aprendizaje basado en proyectos" (ABP) y el "aprendizaje por enseñanza" o "aprender enseñando". En el contexto de este caso de estudio, los proyectos constan de dos partes: *(i)* la generación de un glosario con los términos más relevantes aprendidos en clase, relacionados con la programación. Este glosario se ha dirigido a un público objetivo de niños entre 6 y 8 años. De esta manera, no solo tienen que demostrar que saben el concepto, sino que además son capaces de explicarlo, adaptándolo a otras personas y *(ii)* la realización de una aplicación en ScratchJr y otra en CoSpaces. En este aspecto se ha valorado si son capaces de utilizar los diferentes bloques de los programas asociados a los conceptos vistos en clase. Además, se ha dejado libertad en la selección del tema y la ambientación de los programas desarrollados.

IV. RESULTADOS

A continuación, se presentan los resultados obtenidos mediante la recopilación y análisis de los test, el caso práctico y el proyecto realizado, con el objetivo de evaluar la efectividad de la metodología y las herramientas utilizadas, y validar la hipótesis planteada, así como responder a las preguntas de investigación.

J. Resultados cuantitativos

En esta sección se proporciona la información recopilada a partir de las respuestas cerradas en los test, caso práctico y diferentes partes del proyecto. Esta información se analizó utilizando estadística descriptiva con el *software* Real Statistics Resource Pack (versión 7.6).

La Tabla 2, muestra algunas de las preguntas más relevantes planteadas en el test. Estas preguntas buscan medir la percepción de la utilidad de los entornos de programación para el aprendizaje de los conceptos de programación, así como el grado en que las herramientas pueden complementarse. Es importante destacar que las preguntas se respondieron en una escala de Likert [0,4].

TABLA 2 PREGUNTAS

	Preguntas
P1	¿Cuál era tu nivel de conocimiento en programación antes de las 8 sesiones?
P2	¿Cuánto dirías que ha mejorado tu conocimiento en programación desde el comienzo de la asignatura?
P3	¿Cuánto dirías que entiendes los conceptos básicos de programación como variables, bucles y condicionales?
P4	¿Cómo de útil para entender los conceptos de programación ha sido el uso de metáforas?
P5	¿Cómo de útil fueron las actividades y ejercicios propuestos en clase para mejorar tus habilidades de programación?
P6	¿Cómo de fácil te ha resultado aprender a utilizar Code.org?
P7	¿Cómo de fácil te ha resultado aprender a utilizar ScratchJr?
P8	¿Cómo de fácil te ha resultado aprender a utilizar CoSpaces?
P9	¿Cuánto te ayudó haber trabajado con Code.org para aprender a utilizar ScratchJr?
P10	¿Cuánto te ayudó haber trabajado con Code.org y ScratchJr para aprender a utilizar CoSpaces?

La Figura 1, presenta los resultados numéricos obtenidos para las preguntas de la Tabla 2. Específicamente, se muestran algunos estadísticos descriptivos utilizando un diagrama de caja y bigotes. Este diagrama representa el rango intercuartil, es decir, la diferencia entre el tercer cuartil (Q3) y el primer cuartil (Q1). La línea central dentro de la caja representa la mediana. Las líneas que se extienden desde la caja (los bigotes) representan el rango de los datos, excluyendo los valores atípicos. La media se muestra como una cruz (X) dentro de la caja.

En la Figura 2 se presentan los resultados académicos de los estudiantes obtenidos en el proyecto (glosario, práctica con ScratchJr y CoSpaces) y en el Caso Práctico. Para facilitar el análisis, los resultados se han convertido a una escala [0,4]. Específicamente, la media de los resultados obtenidos para el glosario de ScratchJr, CoSpaces y el Caso Práctico es de 3.2, 3.4, 3.3 y 2.8 respectivamente.

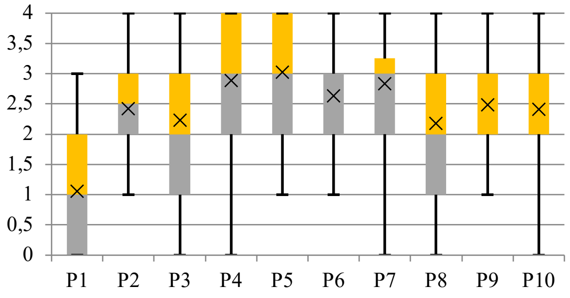


Fig. 1 Resultados obtenidos en las preguntas del test.

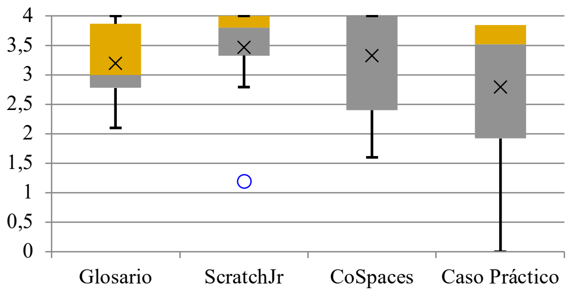


Fig. 2 Resultados obtenidos en el Proyecto (Glosario, ScratchJr y CoSpaces) y en el Caso Práctico.

K. *Resultados cualitativos*

Después de completar las sesiones y las evaluaciones cuantitativas, se solicitó a los estudiantes que expresaran su opinión a través de respuestas a preguntas abiertas. Estas preguntas se enfocaron en evaluar la metodología utilizada (organización en 8 sesiones, herramientas empleadas, proyectos, casos prácticos, etc.) y también el grado general de satisfacción con el proceso de aprendizaje de los conceptos de programación. Se recibieron más de 60 respuestas, ya que se permitía enviar múltiples valoraciones. En su mayoría, las opiniones recibidas fueron positivas. A continuación, se presentan algunas de ellas:

- *"He aprendido el concepto general de qué es la programación y he perdido el miedo a ello."*
- *"He aprendido una nueva herramienta para generar contenido académico y lúdico al mismo tiempo."*
- *"Sinceramente, comencé esta parte de la asignatura con mucho miedo, pero al final logré aprender realmente qué es la programación y cómo usar Scratch."*
- *"He aprendido muchas cosas que puedo utilizar para crear actividades interesantes en el aula. Al principio no tenía ni idea de qué era la programación."*

Estas opiniones en su mayoría pueden considerarse positivas. Además, es importante destacar que 8 opiniones indican que antes de las 8 sesiones los estudiantes tenían miedo de enfrentarse a la programación. Por otro lado, 5 estudiantes también afirman que se sienten motivados para seguir aprendiendo y aplicando estos conocimientos en su futuro profesional. Por último, 38 opiniones indican que el proceso de aprendizaje les resultó entretenido y divertido.

V. Discusión

En esta sección se discuten los resultados obtenidos en relación con las hipótesis y preguntas de investigación planteadas al comienzo del estudio.

En primer lugar, se planteó la pregunta de investigación **RQ1**. Los resultados cuantitativos revelan que los estudiantes tienen una percepción inicial deficiente de la programación, ya que el promedio de los resultados es cercano a 1 (P1). Sin embargo, después de las 8 sesiones y al evaluar su propio conocimiento de programación, se observa un incremento en su percepción, superando en promedio el valor 2 (P2 y P3). Este aumento está directamente relacionado con la valoración positiva de la metodología propuesta.

Estos resultados respaldan la respuesta afirmativa a la pregunta RQ1. Los estudiantes lograron adquirir una comprensión conceptual de la programación informática a través de su participación en las actividades propuestas durante las 8 clases, utilizando las aplicaciones Code.org, ScratchJr y CoSpaces.

Luego, se planteó la pregunta de investigación **RQ2**. El análisis de los resultados indica que el uso de metáforas fue valorado positivamente por los estudiantes, con una puntuación cercana a 3 (P4). Esto sugiere que la estrategia de utilizar metáforas entre el mundo real y el mundo de la programación informática fue efectiva para facilitar la comprensión y el aprendizaje de los conceptos básicos de programación. Por lo tanto, se puede afirmar que el uso de metáforas sí puede mejorar el aprendizaje de conceptos básicos de programación informática, respaldando la respuesta afirmativa a la pregunta RQ2.

Si bien la pregunta **RQ3** no se aborda directamente en los resultados presentados, se puede inferir que la motivación desempeñó un papel importante en el aprendizaje de conceptos básicos de programación informática a través de las aplicaciones propuestas. Las opiniones positivas de los estudiantes, su percepción de la asignatura como interesante y útil, incluso para aquellos sin conocimientos previos de programación, sugieren que la motivación fue un factor clave en el proceso de aprendizaje.

A continuación, se planteó la pregunta de investigación **RQ4**. Los resultados muestran que las aplicaciones Code.org, ScratchJr y CoSpaces fueron valoradas positivamente por los estudiantes, con una puntuación cercana a 3 (P5). Además, se observó que los estudiantes fueron capaces de utilizar estas herramientas de manera efectiva para desarrollar sus proyectos de aplicaciones y juegos de realidad virtual. Por lo tanto, se puede afirmar que el uso de Code.org, ScratchJr y CoSpaces fue útil para enseñar a los estudiantes a crear aplicaciones y juegos de realidad virtual mediante CoSpaces, respaldando la respuesta afirmativa a la pregunta RQ4.

Finalmente, los resultados obtenidos respaldan la hipótesis planteada al inicio del estudio. La participación de los estudiantes en las actividades propuestas les permitió adquirir una comprensión conceptual de la programación informática. Este hallazgo confirma que la metodología utilizada fue efectiva para lograr los objetivos planteados.

VI. CONCLUSIONES

En general, se puede concluir que los resultados obtenidos en este estudio de caso respaldan las hipótesis propuestas y brindan respuestas positivas a las preguntas de investigación planteadas al inicio de la investigación. Los estudiantes lograron adquirir una comprensión conceptual de la programación informática a través de las actividades propuestas, demostrando que la metodología utilizada y las aplicaciones seleccionadas fueron efectivas en su aprendizaje.

Además, el uso de metáforas, junto con las aplicaciones Code.org, ScratchJr y CoSpaces, demostró ser beneficioso para mejorar el aprendizaje de conceptos básicos de programación. La motivación de los estudiantes y su percepción positiva de las actividades y herramientas utilizadas también respaldan la efectividad del enfoque.

Estos resultados tienen implicaciones significativas para la enseñanza de la programación informática a futuros profesores. El estudio sugiere que el uso de actividades prácticas, combinadas con herramientas interactivas y metáforas, puede facilitar la comprensión y el aprendizaje de los conceptos de programación. Además, resalta la importancia de mantener a los estudiantes motivados y comprometidos durante el proceso de aprendizaje, ya que esto puede influir positivamente en su adquisición de conocimientos.

AGRADECIMIENTOS

Agradecemos la participación tanto de los estudiantes involucrados como de los grupos LITE y GUISE.

REFERENCIAS

[1] Papert, S. (1995). Capítullo 1: Anhelantes e Instructores. In S. Papert, La máquina de los niños. Replantearse la educación en la era de los ordenadores. Barcelona: Paidós.

[2] Solomon, C., Harvey, B., Kahn, K., Lieberman, H., Miller, M., L., Minsky, M., Papert, A.y Silverman, B. 2020. History of Logo. Proc. ACM Program. Lang. 4, HOPL, Article 79 (June 2020), 66 pages.

[3] B. Rial-Fernández and L. P. Santacruz-Valencia, "The Teaching of Programming is not the Future but the Present," 2019 International Symposium on Computers in Education (SIIE), Tomar, Portugal, 2019, pp. 1-6, doi: 10.1109/SIIE48397.2019.8970118.

[4] Scherer, R., Siddiq, F., Sánchez Viveros, B. 2020. A meta-analysis of teaching and learning computer programming: Efective innstructional approaches and conditions. Computer in Human Behavior, 109. doi:10.1016/j.chb.2020.106349

[5] Redecker, C. (2017). European Framework for the Digital Competence of Educators: DigCompEdu (Y. Punie, Ed.). Publications Office of the European Union. doi:10.2760/159770

[6] Kluzer, S., & Priego, L. P. (2018). Digcomp into action: Get inspired, make it happen. a user guide to the european digital competence framework (No. JRC110624). Joint Research Centre (Seville site).

[7] R. Vuorikari, M. Cabrera, and O'Keefe, W. (Eds.). JRC Science for Policy Report, EUR 29115 EN, Publications Office of the European Union, Luxembourg, 2018. ISBN 978-92-79-79901-3, doi:10.2760/112945.

[8] Hijón-Neira, R., Santacruz-Valencia, L., Pérez-Marín, D. y Gómez-Gómez, M. (2017). Un análisis de la situación sobre el estado de la enseñanza de la Programación en Primaria y su didáctica. *Atas do XIX Simpósio Inter- nacional de Informática Educativa e VIII Encontro do CIED–III Encontro Internacional* (pp. 103-108). http:// hdl.handle.net/10400.21/11916

[9] INTEF (2017). *Marco Común de Competencia Digital Docente*. Madrid: Ministerio de Educación, Ciencia y Deportes.

[10] Cruz-García, I., Martín-García, J. A., Pérez-Marin, D., & Pizarro, C. (2021). Propuesta de didáctica de la Programación en Educación Primaria basada en la gamificación usando videojuegos educativos. *Education in the Knowledge Society (EKS)*, *22*, e26130. doi:10.14201/eks.26130

[11] Dapozo, Gladys N., et al. "Formación docente para incorporar la programación en las escuelas". En: Marco Galindo, María Jesús; Bañeres Besora, David; Marco Simó, Josep Maria (eds.). Actas de las XXIV Jornadas sobre la Enseñanza Universitaria de la Informática, Barcelona, 4-6 de julio de 2018. Asociación de Enseñantes Universitarios de la Informática, 2018, pp. 31-38

[12] Velázquez-Iturbide, J. Á., Bahamonde, A., Dabic, S., Escalona, M. J., Feito, F., Fernández Cabaleiro, S., Ferrero Martín, B., Garay Vitoria, N., García, J. C., García Borgoñón, L., García Martínez, M., García Molina, J., García Varea, I., Hermenegildo Salinas, M., Larraza Mendiluze, E., Llorens Largo, F., Mateos, J. A., Moratel Muñoz, A., Mozos, D., Pimentel, E., Sahelices, B., Toro, M. y Zapata Ros, M. (2018). *Informe del Grupo SCIE/ CODDII sobre la enseñanza preuniversitaria de la informática. Sociedad Científica Informática de España Conferencia de Decanos y Directores de Ingeniería Informática. https://goo.gl/dmCPgm*

[13] Ouahbi, I., Kaddari, F., Darhmaoui, H., Elachqar, A. y Lahmine, S. (2015). Learning basic programming concepts by creating games with Scratch programming environment. *Procedia-Social and Behavioral Sciences*, *191*, 1479-1482. doi:10.1016/j.sbspro.2015.04.224

[14] Sović, A., Jagušt, T. y Seršić, D. (2014). How to teach basic university-level programming concepts to first graders? En Proceedings of the 2014 IEEE Integrated STEM Education Conference. doi:10.1109/ISECon.2014.6891050

[15] Brackmann, C., Barone, D., Casali, A., Boucinha, R. y Muñoz-Hernandez, S. (2016). Computational thinking: Panorama of the Americas. En *International Symposium on Computers in Education (SIIE)*. doi:10.1109/SIIE.2016.7751839

[16] Conde Melguizo, R., Vega-Barbas, M. y García-Vázquez, C. (2020). Analizando el auge de Scratch para la enseñanza de la programación. Revisión del conocimiento científico publicado en España. *Tarbiya, Revista De Investigación e Innovación Educativa*, *48*, 7-32. doi:10.15366/tarbiya2020.48.001

[17] Wing, J.M. (2008). Computational thinking and thinking about computing. Philosophical Transactions. Series A, Mathematical, Physical, and Engineering Sciences, 366(1881), 3717–3725. doi:10.1098/rsta.2008.0118

[18] Bers, M.U. (2018). Codings as a Playground: programming y Computational Thinking in the Early Childhood Classroom. New York: Routledge.

[19] González, J., Estebanell, M., y Peracaula, M. (2018). ¿Robots o programación? El concepto de pensamiento computacional y los futuros maestros. EKS. *Education in the Knowledge Society,* 19, 29–45. doi: 10.14201/eks20181922945

[20] Sánchez Vera, M. (2022). La robótica, la programación y el pensamiento computacional. Infancia, Educación y Aprendizaje (IEYA). Vol. 7, No 1, pp. 209-234. http://revistas.uv.cl/index.php/IEYA/index

[21] Figueiredo, J., García-Peñalvo, F.J. Design science research applied to difficulties of teaching and learning initial programming. *Univ Access Inf Soc* (2022). doi:10.1007/s10209-022-00941-4

[22] Moons, J. y De Backer C.. 2013. The design and pilot evaluation of an interactive learning environment for introductory programming influenced by cognitive load theory and constructivism. *Computers & Education* 60, 1 (2013), 368–384.

[23] Lodi, M., Malchiodi, D., Monga, M., Morpurgo, A., y Spieler, B. (2019). Constructionist attempts at supporting the learning of computer programming: A survey. *Olympiads in Informatics*, *13*, 99-121. doi:10.15388/ioi.2019.07

[24] Gleasman, C., Kim, C. Pre-Service Teacher's Use of Block-Based Programming and Computational Thinking to Teach Elementary Mathematics. *Digit Exp Math Educ* **6**, 52–90 (2020). doi:10.1007/s40751-019-00056-1

[25] Resnick, M. (2007). All i really need to know (about creative thinking) I learned (by studying how children learn) in Kindergarten. In C&C '07: Proceedings of the 6th ACM SIGCHI Conference on Creativity and Cognition (pp. 1–6). Association for Computing Machinery. doi:10.1145/1254960.1254961

PRO(G)NATURA: TECHNOLOGIE AND OUTDOOR EDUCATION AS A COMPLEMENT TO IMPROVE THE CHILD LEARNING PROCESS

Isabel Duque
CASPAE
Coimbra, Portugal
isabel.duque@caspae.pt

Ricardo Almeida
CASPAE
Coimbra, Portugal
ricardo.almeida@caspae.pt

Emília Bigotte de Almeida
ISEC/IPC
CASPAE
Coimbra, Portugal
mebigotte@gmail.com

Marlene Migueis
DEP/Universidade de Aveiro
CDITFF
Aveiro, Portugal
mmigueis@ua.pt

***Abstract*— According to the literature, the Scratch software, when used in an educational context, can enhance learning in areas as mathematics, science, arts, languages and music. Also education in nature environment has been focus of several studies, which present evidence of its potentiality to the development of curriculum learning, health and well-being. The proposed work aims to present the preliminary results of the impact of an educational program that combines Scratch programming environment and nature environment, as a complement to the classroom context learning. It is an educational program for children attending the 1st Cycle of Basic Education (CEB), called PRO(G)NATURA (PGN), which applies a methodology, centred on students' interests and motivations, through the articulation between education in the nature and Scratch, developed within the scope of the curriculum flexibility recommended for the 1st year of the 1st CEB in Portugal. The presented study refers to the participation of 56 students in PGN in the academic year 2018/2019. The study aims to understand the potential of the educational program for the development of children's learning. To this, at the end of the program, the children' parents/guardians had access to a questionnaire. A preliminary data reading shows that, according to the 33 carers answering the questionnaire, PGN had a positive impact on the development and learning of the participants. They was also perceived changes at children' skills while participating in the program.**

Keywords*— *Curriculum flexibility, technology education, outdoor education, learning

I. Introduction

To break the boundaries between knowledge areas and to make the learning process a meaningful knowledge development and construction process, the Curriculum Autonomy and Flexibility Project (CAFP) is being implemented in Portugal. This is a measure aimed at introducing means of organization and curriculum development that focus on the student and essential learning [1]. This measure gives schools the management of curriculum and the organization of subject areas in order to achieve the competencies provided for in the so-called "Student Profile on Exit from Compulsory Education" (SP). As a result of the flexibility management plan implementation, the "Curricular Autonomy Domains" (CAD) are understood as the development of interdisciplinary work and/or curriculum articulation integrating the organization of the disciplinary areas [2]. This educational measure aims to enable the school to enhance the relationship between the individual and society, preparing the student for the challenges of a society in constant change, in terms of knowledge and technology.

In the 1st Cycle of Basic Education (CBE) - elementary school - learning must be active, meaningful, diverse, integrative and socializing. The curriculum should be regulated by an integration code, mainly because there is only one teacher and there is no pre-determined time/space for each subject area [3]. The challenge of today's school is curriculum integration, with proposals that challenge students to develop researches, and this process should not be limited to a classroom and teacher, but rather organized as an open and contextualized environment [4].

Understanding that experiences in the early years life have a lasting impact on the future lives of children, PGN is an educational program that focuses on children attending the 1st CBE (6-10 years). Framed within the framework of CAFP development, this educational program articulates three educational environments: classroom, Scratch programming and outdoor. It is intended that the students can develop the syllabus in a playful and motivating way, giving meaning to the learning in order to achieve better results, namely with regard to the competences development according to the SP [5].

The present paper aims to present the preliminary results of the PGN impact during the first year of implementation on the children learning development, according to parents/guardians.

II. Nature and Technology

In a society increasingly dependent on new technologies, we must recognize the importance and presence of computers, and other forms of technology in students' daily lives. In the classroom, programming software has been used as a way to develop fundamental skills for the 21st century. The literature presents numerous examples of the use of programming software, dedicated to the development of technological skills in children. Scratch software, developed by the Lifelong Kindergarten Group at the Massachusetts Institute of Technology (MIT) Media Laboratory, for example, is a very simple and intuitive programming language that enables learning in different subjects such as math, science, arts, music or languages and to the development of problem-solving skills [6], [7].

At the same time, scientific and educational community has come to realize that children's contact with nature has been drastically decreasing during last decades [8]. According to the literature, physical inactivity has contributed to the increase in health problems affecting children in recent decades, including chronic conditions of childhood obesity, asthma, attention deficit and hyperactivity [9]. Understanding the negative impact of this nature contact decline, Scandinavian outdoor education programs have inspired other countries and the scientific community, which is now seeking to understand the potential of nature education for children's development. Research in this area [9], [10], [11] shows that outdoor educational programs, such as those developed in Scandinavia, have positive effects on health, psychomotor development and cognitive skills development, such as problem-solving skills, observation skills, and creativity. Practical activities outside the classroom allow students to understand the benefits of learning school content, with learning in nature being identified as a potential environment to increase the development of science process skills and problem-solving skills [12], [13].

PGN, in its outdoor education strand, is inspired by the Scandinavian approach to out-of-school education for children aged 7 to 16, designated in Denmark by *udeskol*. This is a recent approach but based on the traditional education in the natural environment developed in the Nordic countries several decades ago for children up to 6 years old, the *skov* and *natur børnehave* .

In Denmark, the development of the *udeskol* approach has been enhanced and monitored by the *Udvikling af Udeskole Project*, funded by the Ministry of Education and the Ministry of Environment, in collaboration with a partnership formed by VIA University College (responsible for project implementation); *Professionshøjskolen Metropol*; "*Videncenter for Naturformidling og Friluftsliv*", University of Copenhagen, and Steno Diabetes Centre, Health Promotion Research [14]. This approach that enhances the involvement of all curriculum areas in an integrated and authentic way has more and more followers. In Denmark, between 2007 and 2014, there was a reported increase from 290 to 344 schools adhering to this approach [15]. Basically, this approach refers to the development of activities to explore the environment outside the school space, intentionally for the development of a specific curricular learning [16].

Thus, also in the PGN's development, each of the actions is planned in articulation with the Classroom Teachers. The outdoor class start from the free initiative of the students and focus on curricular topics under study. These experiences are later explored using the Scratch programming language, creating opportunities for building/consolidating students' skills [5].

III. PGN: Educational Programme

PGN is the result of a partnership between three community projects, each developed by several entities: (i) *Trampolim E7G* Project, (ii) *Limites Invisíveis* Project and (iii) All in Scratch Project. Within the scope of social responsibility, PGN is the result of the several institutions cooperation, to aim to improve the child learning process.

PGN is an educational programme that assumes a regular participation in the nature and technological environment with Scratch, allied to the benefits of both environments to the one that usually develops in a classroom at this stage. During the school year, once a week, from 9h00m to 15h00m, students have the opportunity to have contact with nature to develop exploration activities. Also, weekly, lasting 60 minutes, students have the possibility to use Scratch software to create technological products that allow the transposition of experiences developed in nature. Starting from the free initiative of the students, all the activities are related with curricular program. This alliance between nature, technology and classroom, can enhance the learning promotion in all areas of knowledge, but also the motivation of students to learn.

PGN programme, being part of the CAFP of the schools in which it is implemented, aims to develop the CAD. Therefore, promoting, the learning contemplated in SP, grouped in the following areas: (i) specific competencies related with the adoption of adapted behaviours to the both environments in which the program is developed - nature and technological; (ii) global skills related to the effective use of codes enabling the expression, representation, selection and dissemination of knowledge, and (iii) transversal skills connected to decisions making, interpersonal interaction social integration [5].

The specific PGN main goals, designed in connection to SP, are [5]: Enable free nature's and technology's exploitation, promoting collaboration environment; Mobilize various languages to build knowledge, and share meanings in different knowledge areas; Encourage creativity and collaborative work through the design of scenarios for the ideas application that promote environmental and civic responsibility; Design learning environments capable to promote interest in science, math and technology through a creative, experimental and exploratory approach; Articulate digital programming tools with exploration in outdoor environment, that offering exploration of resources, problems and themes for an integrated understanding of knowledge; Promote digital and technological-educational knowledge; Develop computational thinking and digital fluency; Provide opportunities for recognition, assessment and overcoming the risks that nature offers; Promote the development of motor skills and resilience.

Those main goals include the following skills areas contemplated in the SP [5]:

- Specific: (i) Critical and creative thinking; (ii) Scientific, technical and technological knowledge, (iii) Aesthetic and artistic sensibility, (iv) Welfare, health and environment, and (v) Body Awareness and Mastery;
- General: (i) Languages and Texts and (ii) Information and Communication;
- Transversal: (i) Reasoning and problem solving; (ii) Interpersonal relationship, and (iii) Development and autonomy.

IV. Context and Method

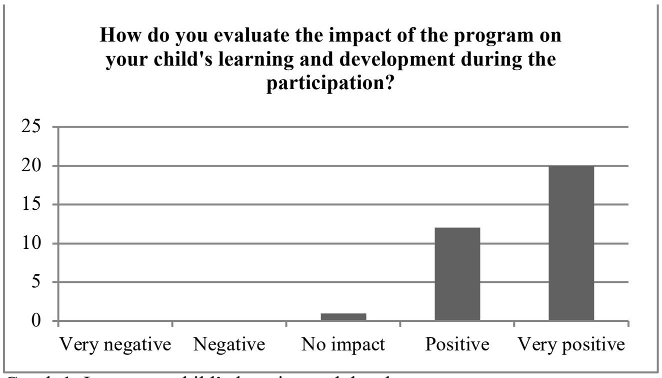
This study was carried out in the 1st year of PGN's implementation, which has duration of 4 years, being therefore part of a larger study. It is based on the participation of a total of 56 children from three 1st grade classes and their teachers in PGN year 1, developed during school year 2018/2019. Class A, with 15 students, held a total of 27 outdoor class and 26 sessions in a Scratch environment. Class B, with 17 students, held a total of 21 outdoor class and 26 sessions in a Scratch environment. Class C, with 24 students, held a total of 24 outdoor class and 26 sessions in Scratch environment. Each weekly nature class had a daily duration of about 5 hours and the weekly session in Scratch environment lasted approximately 60 minutes.

The development of the outdoor class resulted in the exploration of different themes, in articulation with the goals set by the teachers' according to SP. During the Scratch programming sessions, dedicated to this first year of implementation to develop basic digital skills, children explored the tool using their experiences in nature.

At the end of the school year, parents of participants had access to a questionnaire to collect data to aim understand their perception about the impact of PGN on children's learning. Of the 56 participating students, 33 parents/guardians answered the questionnaire: from Class A we received the participation of 3 parents; 10 parents from Class B, and 20 parents from Class C students. The questions under analysis are part of a larger questionnaire, focusing here on those that allow us to respond to the objective of the study presented here. The preliminary analysis of the data was performed using Excel, which allow us to reach some results about the parents' perception about the possible impact of the children's participation in the program, in terms of their learning development.

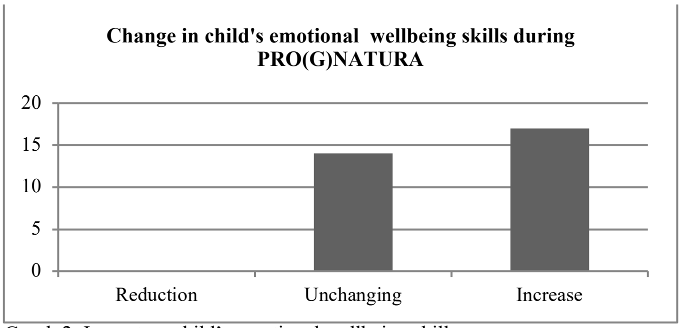
V. Preliminary Results

In order to understand the impact of PGN on children's learning and development, parents answered to the question: "How do you evaluate the impact of the program on your child's learning and development during the participation?". As we can see in Graph 1, from the 33 parents/guardians who answered the question, 20 parents/guardians sign the impact was very positive, 12 parents/guardians sign there was a positive impact and only 1 parent/guardian sign he had no perceived any impact. There was no references to a negative impact of PGN on learning and/or learning child development.



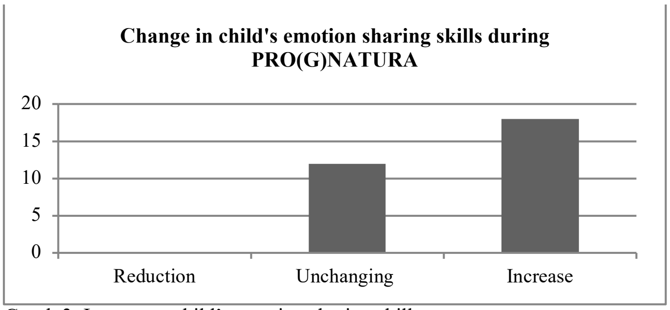
Graph 1: Impact on child's learning and development

The child's emotional wellbeing skills level before and after participating in PGN was assessed by 31 of the 33 parents/guardians who answered the questionnaire. Graph 2 shows that 17 parents/guardians considered having identified their child's emotional wellbeing skills increased between the two assessment moments, and 14parents/guardians indicated that they did not perceive changes in the development of these skills between the two assessment moments.



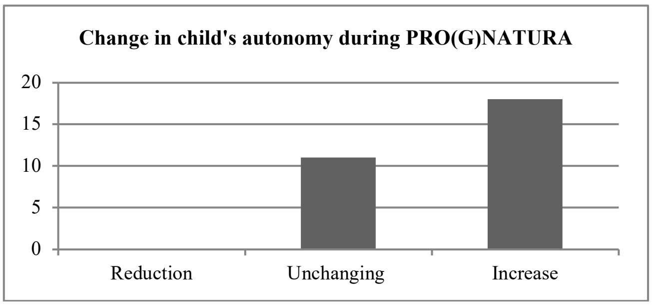
Graph 2: Impact on child's emotional wellbeing skills

Child's emotion sharing skills level before and after participating in PGN was assessed by 30 of the 33 parents/guardians who answered the questionnaire. Graph 3 shows that 18 parents/guardians considered having identified their child's emotion sharing skills increased between the two assessment moments, and 12 parents/guardians indicated that they did not perceive changes in the development of these skills between the two assessment moments.



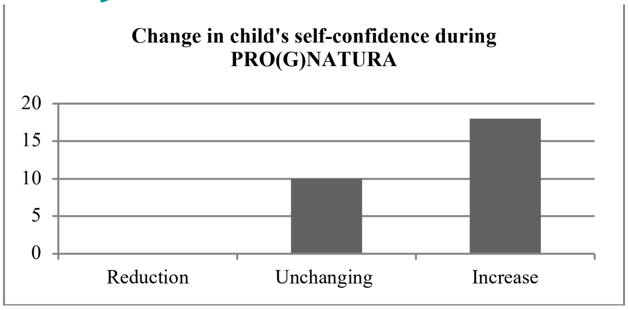
Graph 3: Impact on child's emotion sharing skills

Child's autonomy level before and after participating in PGN was assessed by 29 of the 33 parents/guardians who answered the questionnaire. Graph 4 shows that 18 parents/guardians considered having identified their child's autonomy increased between the two assessment moments, and 11 parents/guardians indicated that they did not perceive changes in the development of child's autonomy the two assessment moments.



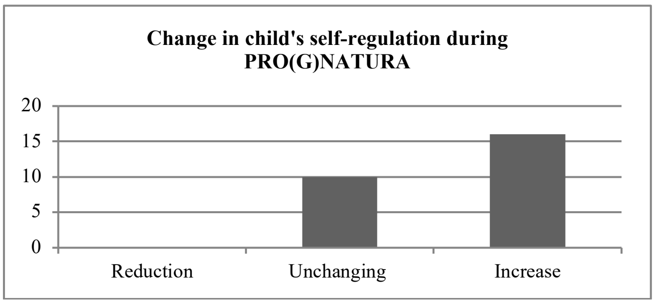
Graph 4: Impact on child's autonomy

The child's self-confidence skills level before and after participating in PGN was assessed by 28 of the 33 parents/guardians who answered the questionnaire. Graph 5 shows that 18 parents/guardians considered their child have more self-confidence at the end of the programme, and 10 parents/guardians indicated that they did not perceive changes in the development of self-confidence skills between the two assessment moments.



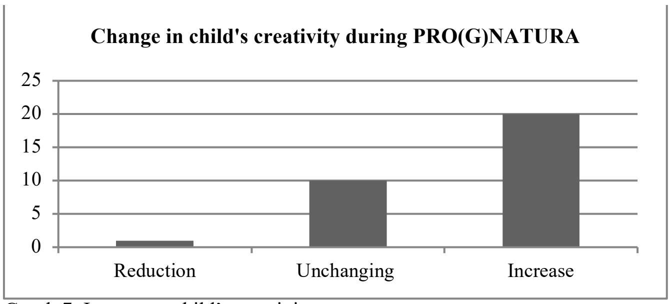
Graph 5: Impact on child's self-confidence

Child's self-regulation skills level before and after participating in PGN was assessed by 26 of the 33 parents/guardians who answered the questionnaire. Graph 6 shows that 16 parents/guardians considered having identified their child's self-regulation skills level increased between the two assessment moments, and 10 parents/guardians indicated that they did not perceive changes in the development of child's autonomy the two assessment moments.



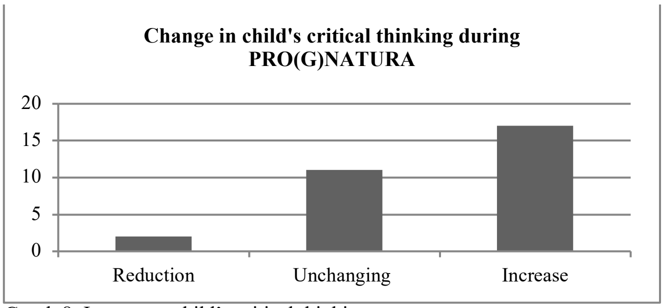
Graph 6: Impact on child's self-regulation

The child's creativity skills level before and after participating in PGN was assessed by 31 of the 33 parents/guardians who answered the questionnaire. Graph 7 shows that 20 parents/guardians considered having identified their child's creativity skills increased between the two assessment moments. 10 parents/guardians indicated that they did not perceive changes in the development of these skills between the two assessment moments, and 1 parent/guardian sign he had perceived the reduction in the child's level of creativity skills.



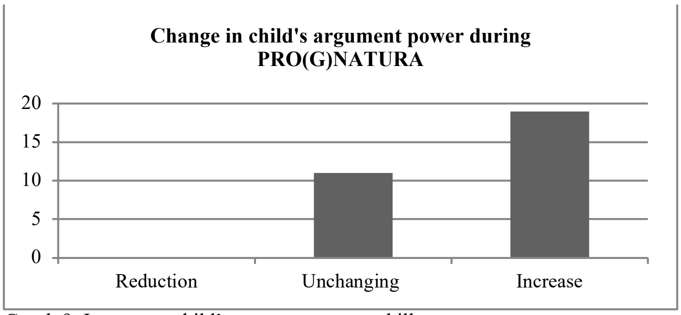
Graph 7: Impact on child's creativity

Child's critical thinking skills level before and after participating in PGN was assessed by 30 of the 33 parents/guardians who answered the questionnaire. Graph 8 shows that 17 parents/guardians considered having identified their child's critical thinking skills increased between the two assessment moments, and 11 parents/guardians indicated that they did not perceive changes in the development of these skills between the two assessment moments. 2 parent/guardian perceived the reduction in the child's level of critical thinking skills during de PGN development.



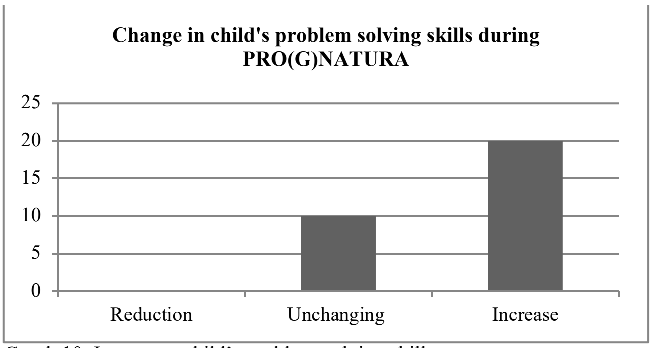
Graph 8: Impact on child's critical thinking

The child's argument power skills level before and after participating in PGN was assessed by 30 of the 33 parents/guardians who answered the questionnaire. Graph 9 shows that 19 parents/guardians considered their child have more argument power at the end of the programme, and 11 parents/guardians indicated that they did not perceive changes in the development of argument power skills between the two assessment moments.



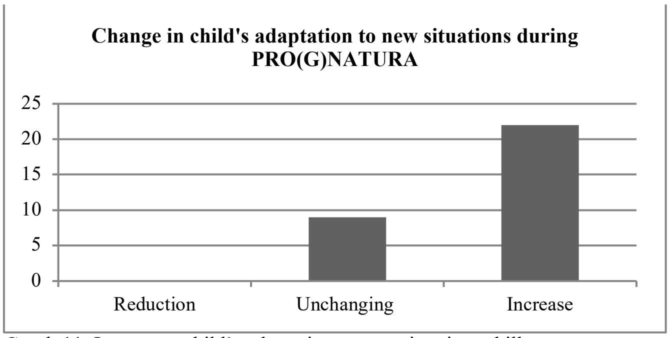
Graph 9: Impact on child's argument power skills

The child's problem-solving skills level before and after participating in PGN was assessed by 30 parents/guardians who answered the questionnaire. Graph 10 shows that 20 parents/guardians considered having identified their child's problem-solving skills increased between the two assessment moments, and only 10 parents/guardians indicated that they did not perceive changes in the development of these skills between the two assessment moments.



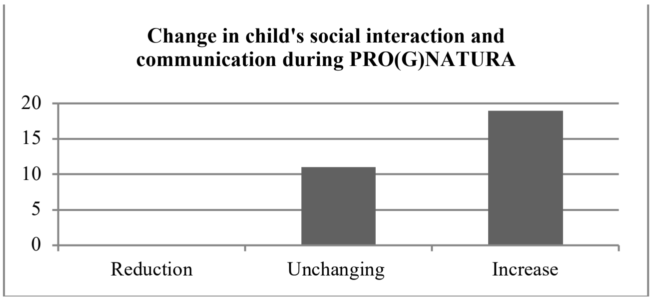
Graph 10: Impact on child's problem-solving skills

Child's adaptation to new situations skills level before and after participating in PGN was assessed by 31 parents/guardians who answered the questionnaire. Graph 11 shows that 22 parents/guardians considered having identified their child's adaptation to new situations skills level increased between the two assessment moments, and 9 parents/guardians indicated that they did not perceive changes in the development of child’s adaptation to new situations skills.



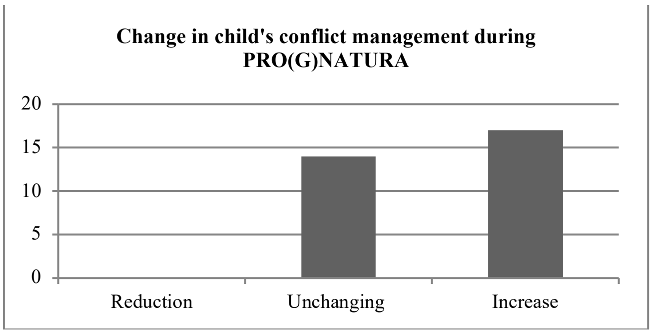
Graph 11: Impact on child’s adaptation to new situations skills

The child's social interaction and communication skills level before and after participating in PGN was assessed by 30 parents/guardians who answered the questionnaire. Graph 12 shows that 19 parents/guardians considered having identified their child's social interaction and communication skills increased between the two assessment moments, and only 11 parents/guardians indicated that they did not perceive changes in the development of these skills between the two assessment moments.



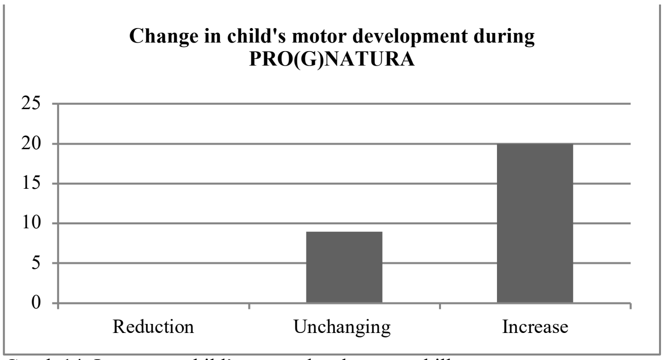
Graph 12: Impact on child’s social interaction and communication skills

Child's conflict management skills level before and after participating in PGN was assessed by 31 of the 33 parents/guardians who answered the questionnaire. Graph 13 shows that 17 parents/guardians considered having identified their child's conflict management skills level increased between the two assessment moments, and 14 parents/guardians indicated that they did not perceive changes in the development of child’s conflict management skills.



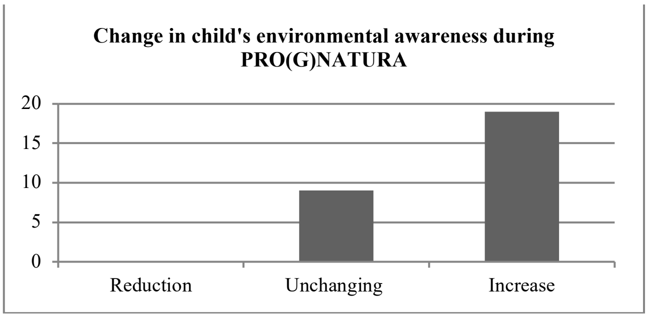
Graph 13: Impact on child’s conflict management skills

The child's motor development skills level before and after participating in PGN was assessed by 29 parents/guardians who answered the questionnaire. Graph 14 shows that 20 parents/guardians considered having identified their child's motor development skills increased between the two assessment moments, and 9 parents/guardians indicated that they did not perceive changes in the development of these skills between the two assessment moments.



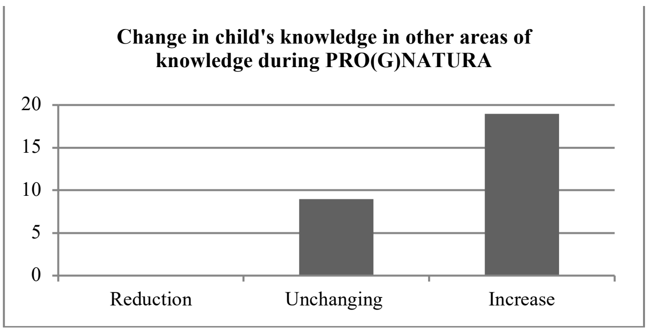
Graph 14: Impact on child’s motor development skills

Child's environmental awareness skills level before and after participating in PGN was assessed by 28 parents/guardians who answered the questionnaire. Graph 15 shows that 19 parents/guardians considered having identified their child's environmental awareness skills level increased between the two assessment moments, and 9 parents/guardians indicated that they did not perceive changes in the development of child’s environmental awareness skills.



Graph 15: Impact on child’s environmental awareness skills

The child's Impact on child’s environmental awareness skills level before and after participating in PGN was assessed by 28 parents/guardians who answered the questionnaire. Graph 16 shows that 19 parents/guardians considered having identified their child's knowledge in other areas of knowledge increased between the two assessment moments, and only 9 parents/guardians indicated that they did not perceive changes in the development of that knowledge between the two assessment moments.



Graph 16: Impact on child’s Impact on child’s environmental awareness skills

Preliminary analysis of the answers given by parents/guardians allows us to understand that participation in PGN allowed parents/guardians to perceive the occurrence of the learning and development of children. This analysis also allows us to understand that, from the parents' perspective, children's participation in PGN will have enhanced the development of the fifteen competencies considered for analysis.

VI. Conclusion

The benefits of outdoor learning have been analysed over the last decades, showing evidences of its positive impact in areas such as health, environmental preservation and the development of personal, social and academic competences [8], [9], [10], [11], [12], [13]. Also, the benefits of learning environments using technology have been presented in recent years, being the Scratch software one of the tools studied because of the positive impact on the learning of children who use this tool in school environment [6], [7]. What PGN proposes and develops is the use of these two environments, as complementary, in the development of CAFP and, therefore, combining these environments with the classroom for the development of an integrated curriculum focused on the interests of children.

From the initiative of the child in nature, the themes and projects arise, and they promote the emerging planning by adults. Regarding the child's action as primordial, the adult identifies opportunities for the SP development, emerging from this identification the planning of educational action. These student experiences are explored in nature and transferred to the classroom and Scratch programming environment, thus allowing students to continue their explorations while simultaneously mobilizing the knowledge already acquired.

Beginning in 2018/2019 as part of the development of the CAFP in three schools of the Rainha Santa Isabel school cluster, PGN developed with 3 classes from the 1st year of the 1st CEB. It is expected to develop throughout the first cycle of studies, ie for 4 years.

At the end of the first year of implementation, participants' parents/guardians were surveyed using a questionnaire. Preliminary data analysis allows us to ascertain that, overall, this educational programme has had a positive impact on the development of children's learning. For about 96% of parents/guardians, PGN will have had a positive or very positive impact on children's learning and development. This analysis also allows us to understand that, according to the participants' parents/guardians, the educational programme has enhanced the development of important essential skills. For 55% of parents, PRO (G) NATURA will have promoted increased emotional wellbeing, critical thinking, conflict management. 58% of parents/guardians consider that during the PGN development they have recognize an increase in emotion sharing, autonomy and self-confidence. For 51% of parents, during PGN there have been increased self-regulation development. 65% of parents/guardians report recognized an increase of creativity, problem-solving skills and motor skills development. For 61% at the parents/guardians, there have been an increase in argument power skills, social interaction and communication skills, environmental awareness and knowledge in other areas of knowledge. And, to 68% of parents/guardians, during PGN there have been increased ability to adapt to new situations.

Although the present analysis is still preliminary, the results presented allow us to understand the potential of this educational offer. Taking into account not only these data, but also the perceptions of the participants, the school principals, teachers, technicians and coordinators involved in this program, PGN is being extended to other classes, thus giving meaning to training promoted to teachers, but also to the main goal of this program: to make the educational community, families and the general community aware of the importance of promoting contextualized, student-cantered approaches and therefore meaningful and lasting learning.

References

[1] A. Santos & C. Leite. Políticas curriculares em Portugal: fronteiras e tensões entre prescrição, autonomia e flexibilidade ().

[2] C. Palmeirão & J. Alves. Construir a autonomia e a flexibilização curricular. In C. Palmeirão & J.Alves (Coor.). Construir a autonomia e a flexibilização curricular: os desafios da escola e dos professores (pp. 4-6). Porto: Universidade Católica Editora, 2017.

[3] I. Neves & A. Morais. Processos de recontextualização num contexto de flexibilidade curricular – Análise da actual reforma das ciências para o ensino básico. Revista de Educação, XIV, pp.75-94, 2006.

[4] J. Machado. Organização e currículo: em busca de um modelo alternativo. In C. Palmeirão & J.Alves (Coor.). Construir a autonomia e a flexibilização curricular: os desafios da escola e dos professores (pp. 25-37). Porto: Universidade Católica Editora, 2017.

[5] E, Almeida, R. Almeida, I. Duque, & C. Mendes. PGN – A tecnologia em articulação com a educação na natureza. Atas 14ª Conferência Ibérica de Sistemas e Tecnologias de Informação, 19 a 22 julho. Coimbra: CISII, 2019.

[6] T. Ferrer-Mico, M. À. Prats-Fernàndez, and A. Redo-Sanchez, "Impact of Scratch Programming on Students' Understanding of Their Own Learning Process," Procedia - Soc. Behav. Sci., 2012.

[7] F. Kalelioğlu and Y. Gülbahar, "The Effects of Teaching Programming via Scratch on Problem Solving Skills: A Discussion from Learners' Perspective," 2014.

[8] L. Delaney and J. Smith, "Childhood health: Trends and consequences over the life course. The future of children", vol. 22, no 1, 43-63, 2012.

[9] D. Erickson and J. Ernst, "The real benefits of nature play every day", NACC Newsletter, pp. 97-100, 2011.

[10] Fjørtoft, "The natural environment as a playground for children: The impact of outdoor play activities in pre-primary school children", Early Childhood Education Journal, vol. 29, no 2, pp. 111-117, 2001.

[11] S. Muñoz, "Children in the Outdoors", UK: Sustainable Development Research Centre, 2009.

[12] H. Dismore, R. Bailey. "If only": Outdoor and adventurous activities and generalised academic development. *Journal of Adventure education and Outdoor Learning, 5(1)*, 9-19. 2005.

[13] S. Wahyuni, Indrawati, Sudarti, W. Suana. Developing science process skills and problem-solving abilities based on outdoor learning in junior high school. Jurnal Pendidikan IPA Indonesia, 6 (1) 165-169, 2017.

[14] P. Bentsen, M. Stevenson, E. Mygind, K. Barfod, K. Education outside the classroom in a Danish context. In Huang, Mao Tsai, Jade Ho 何宜謙, Yi Chien (Ed.), *Budding and Blooming of Outdoor Education in Diverse Global Contexts* (pp. 81-114). Taiwan: National Academy for Educational Research, 2018.

[15] Ejbye-Ernst, N. & Bentsen, P. (2015). Undersøgelse af udbredelsen af udeskole i 2014.

[16] P.Bentsen, F. Jensen, The nature of udeskole: outdoor learning theory and practice in Danish schools. Journal of Adventure Education & Outdoor Learning, Vol. 12(3), 199–219, 2012.

INSTRUMENTOS PARA LA EVALUACIÓN DE LA PERCEPCIÓN Y LA ACTITUD HACIA EL PENSAMIENTO COMPUTACIONAL

Instruments for the assessment of perception and attitude towards computational thinking

1st Gara Miranda
Dpto. de Ingeniería Informática y de Sistemas Universidad de La Laguna
Tenerife, Spain gmiranda@ull.edu.es

2nd Helena Bonache
Dpto. de Psicología Cognitiva, Social y Organizacional Universidad de La Laguna
Tenerife, Spain hbonache@ull.edu.es

3rd Rafael Herrero-A´ lvarez
Dpto. de Ingeniería Informática y de Sistemas Universidad de La Laguna
Tenerife, Spain rherrero@ull.edu.es

4th Enrique Callejas
Diseños de Investigación y Análisis de Datos Universidad Europea de Canarias
Tenerife, Spain
enrique.callejas@universidadeuropea.es

5th Eduardo Segredo
Dpto. de Ingeniería Informática y de Sistemas Universidad de La Laguna
Tenerife, Spain esegredo@ull.edu.es

6th Coromoto Leo´n
Dpto. de Ingeniería Informática y de Sistemas Universidad de La Laguna
Tenerife, Spain cleon@ull.edu.es

***Resumen*—La última reforma educativa de nuestro país incorpora entre sus competencias la resolución de problemas a través del pensamiento computacional. Esto supone un cambio de paradigma a nivel formativo: las personas no serán meras usuarias de la tecnología sino que, desde jóvenes, adquirirán habilidades para ser creadoras y desarrolladoras en este mundo digital. Sin embargo, no es sencillo adaptarse a los cambios e introducir nuevos contenidos sin una formación adecuada. Por este motivo, el presente estudio pretende dar respuesta a preguntas imprescindibles para la incorporación inminente del pensamiento computacional en el currículo: ¿tiene el profesorado una formación y, sobre todo, una actitud favorable hacia la incorporación de estas nuevas competencias en su práctica docente? y, por último, ¿que´ predisposición tiene el alumnado a trabajar este tipo de contenidos? Tras realizar una revisión sistemática de la literatura hemos identificado 22 instrumentos que analizan las actitudes del alumnado y profesorado hacia el pensamiento computacional. Contar con herramientas fiables y con buenas propiedades psicométricas permitirá´ realizar este tipo de diagnóstico en cualquier etapa educativa no universitaria.**

The latest educational reform in our country includes, among its competencies, problem-solving through computational thinking. This represents a paradigm shift in education: individuals will not merely be users of technology but, from a young age, will acquire skills to become creators and developers in this digital world. However, adapting to these changes and introducing new content without adequate training is not straightforward. For this reason, the present study aims to address essential questions for the imminent integration of computational thinking into the curriculum: Does the teaching staff have the necessary training and, above all, a favorable attitude towards incorporating these new competencies into their teaching practice? Lastly, what disposition do students have to engage with this type of content? After conducting a systematic review of the literature, we have identified 22 instruments that analyze the attitudes of both students and teachers towards computational thinking. Having reliable tools with good psychometric properties will enable this type of diagnosis at any non-university educational stage.

***Index Terms*—Computational thinking, elementary and secondary education, assessment instruments, attitudes, emotions.**

Este trabajo se enmarca en el proyecto “El pensamiento computacional en el sistema educativo canario: diagnóstico y hoja de ruta para su incorporación en el currículo”, cuyo acrónimo es C4 (Curriculum de Ciencias de la Computación en Canarias) financiado por la Fundación Caja Canarias-LaCaixa (REF 2020EDU01). Este trabajo también ha recibido el apoyo del proyecto “Piens@ Computacion@ULLmente: Programa educativo para el fomento del pensamiento computacional a través de la realización de actividades que permitan su desarrollo y su inclusión en el currículo” (REF 21120050) financiado por el Cabildo de Tenerife.

I. INTRODUCCIÓN

Hace ya décadas que los ordenadores se han convertido en el gran motor de la innovación y el desarrollo tecnológico de la sociedad moderna. Es por ello que, en su momento, muchos países decidieron incluir competencias digitales en sus currículos educativos con la finalidad de incorporar al mundo laboral a profesionales alfabetizados digitalmente y con habilidades para poder usar correctamente las herramientas y tecnologías de su entorno. Sin embargo, conforme la tecnología avanza y las herramientas digitales se vuelven cada vez más flexibles y potentes, la inclusión de asignaturas puntuales en los planes de estudio se evidencia insuficiente, ya que solo permiten desarrollar en el alumnado destrezas para el manejo de un conjunto de herramientas concretas. En este sentido, sería más positivo y enriquecedor para las personas que viven en una sociedad digital desarrollar destrezas para adecuarse a las nuevas tecnologías y herramientas que irán surgiendo y, al mismo tiempo, poder adquirir las habilidades suficientes para poder crear sus propias herramientas o llevar a la realidad sus propios proyectos tecnológicos [1].

Para trabajar en esta línea, hace ya unos años que se ha comenzado a impulsar activamente un nuevo enfoque de enseñanzas que incluya el pensamiento computacional (del inglés, *Computational Thinking*) en todos los niveles educativos [2]. El pensamiento computacional (PC) podría describirse como los procesos de pensamiento implicados en la formulación de problemas y representación de sus soluciones, de manera que dichas soluciones puedan ser ejecutadas por un agente de pro- cesamiento de información (ya sea un humano, un ordenador o combinaciones de ambos) [3]. Este término cobro´ notoriedad gracias a un artículo de J. Wing [4] en el que se introdujo el pensamiento computacional como un procedimiento que permite la resolución de problemas, el diseño de sistemas y la comprensión de la conducta humana haciendo uso de conceptos fundamentales de la Informática.

Este tipo de pensamiento es el que desarrollan de forma implícita quienes se dedican a la programación o desarrollo de aplicaciones informáticas [5]. En este proceso interviene mucho la creatividad de la persona, pero también su capacidad para entender el problema, el entorno y ofrecer una solución al mismo [6]. Se ha demostrado que estas habilidades pueden desarrollarse progresivamente mediante la práctica con ejercicios y herramientas específicas [7]. Algunos autores afirman que la programación implica que el alumnado haga uso del PC a través de la construcción de artefactos [8], [9]. Esto plantea que *la programación, como la escritura, es un medio de expresión y un punto de partida para desarrollar nuevas formas de pensar*. También es posible desarrollar el PC, incluso cuando no se está utilizando algún tipo de herramienta informática. De hecho, existen propuestas de actividades “desenchufadas” (*unplugged*) diseñadas específicamente para desarrollar el PC. Aunque aún se requiere más investigación que permita identificar que variables actúan como facilitadoras en el proceso de enseñanza-aprendizaje y cuáles pueden suponer una barrera, la evidencia ha mostrado que las actitudes hacia el PC tienen un papel fundamental en su enseñanza y en su aprendizaje, en el rendimiento académico en áreas relacionadas y en la elección de la carrera profesional [10], [11]. A pesar de su relevancia, son pocos los estudios que analizan estas variables en los miembros de la comunidad educativa. Esto revela una carencia de instrumentos fiables y con buenas propiedades psicómetra- cas para la medición de estas actitudes, lo que supone una limitación del alcance teórico y práctico de los hallazgos. El presente estudio examina, a través de una revisión sistemática de la literatura, los instrumentos empleados para evaluar las actitudes y percepciones hacia el PC en el alumnado y el profesorado. El resto del trabajo se estructura de la siguiente forma. En la Sección II se presenta la situación actual de las Ciencias de la Computación en los sistemas educativos. Tras esta contextualización, en la Sección III se fijan los objetivos de la investigación. La metodología utilizada para la revisión sistemática así como una descripción de los instrumentos detectados se presentan en la Sección IV y V, respectivamente. El trabajo finaliza con unas breves conclusiones.

II. ANTECEDENTES

Además de aprender a pensar de forma diferente y desarrollar habilidades para analizar problemas cotidianos y resolverlos, el fomento del PC también permite impulsar el crecimiento económico gracias a la innovación, al diseño de procesos (o productos) más eficientes y a la disposición de profesionales preparados para el empleo del futuro. Por este motivo, en 2015 se elaboró un informe titulado “Educación de las Ciencias de la computación en España” en el que se analizaba el estado de la enseñanza de Informática en dicho país [12]. Cabe puntualizar que, aunque muchos de estos informes hablen de Ciencias de la computación (procede de la traducción al español del término anglosajón “Computer Science”) en España el término Informática esta´ mucho más extendido y reconocido [13]. En él se identificaron algunas de las variables influyentes en el proceso de elección de este itinerario formativo, proponiendo una serie de recomendaciones para la introducción, expansión y mejora de la enseñanza de esta materia en el corto y medio plazo. El informe ponía de manifiesto que existía un desconocimiento generalizado en la sociedad española sobre las Ciencias de la Computación en si mismas y sobre las materias que estas engloban. Tal desinformación se debe a la escasa presencia de las Ciencias de la Computación en el currículo escolar y supone una barrera crítica para entender la importancia de esta materia y el valor de su aprendizaje desde edades tempranas.

En 2016, la agenda de capacidades para Europa se centro´ en la necesidad de desarrollar habilidades digitales para promover la empleabilidad. La agenda invitaba a los Estados miembros a invertir más en la formación de habilidades digitales en todo el espectro de la educación (formal y no formal) y la formación a lo largo de la vida. Es importante remarcar la diferencia entre competencias digitales y otras competencias que están más vinculadas al campo de la Informática como, por ejemplo, el PC. Mientras que las competencias digitales tradicionalmente se han centrado en el mero “uso” de la tecnología [13], estudiar Ciencias de la Computación se centra en entender lo que hay detrás de la tecnología para poder “crear” a partir de ella [14]. Esto supone un cambio de visión: los profesionales del siglo XXI no deben ser simples usuarios de la tecnología, sino que deben entender los fundamentos básicos de la Informática para ser capaces de discernir que´ puede ofrecernos la tecnología en cada contexto y que podría hacer por nosotros a la hora de materializar nuestras ideas, proyectos o simplemente a la hora de mejorar la productividad en nuestra empresa.

Dada estas circunstancias, son muchos los países que han apostado por la introducción del PC en sus currículos educativos [15]. En algunos casos, se ha introducido de forma específica mediante asignaturas, ya sean optativas u obligatorias. En otros casos, se ha incorporado como una competencia transversal; algunos lo han introducido desde edades tempranas y otros solo a partir de secundaria; algunos ya lo han materializado oficialmente en sus currículos, y otros están en proceso de implantación de los nuevos currículos.

En la reciente reforma del sistema educativo español [16], ya aparecen explícitamente en el currículo competencias relacionadas con la resolución de problemas, el PC, la programación y la robótica. De hecho, se establece que, al finalizar la educación primaria, el alumnado debería saber cómo *"desarrollar aplicaciones informáticas sencillas y so- luciones tecnológicas creativas y sostenibles para resolver problemas concretos o responder a retos propuestos de manera creativa"*. Esto implica indirectamente que la programación y la robótica educativa comenzarán a tener presencia en las aulas. Estas competencias, desarrolladas de forma transversal en la educación primaria, se continuarán fomentando durante la educación secundaria en algunas asignaturas obligatorias y también en algunas optativas, como Tecnología.

En los últimos años, muchos otros países europeos también han revisado sus planes de estudios obligatorios e introducido conceptos básicos de las Ciencias de la Computación. El Plan de Acción de Educación Digital 2021-2027 de la Comisión Europea señala que la enseñanza de la Informática de calidad es un elemento clave dentro de la prioridad *"Mejorar las capacidades y competencias digitales para la transformación digital"*. En un reciente informe [17] se han analizado los principales avances relacionados con la integración de las habilidades de PC en la educación obligatoria en Europa entre 2016 y 2021. En el informe se plantean estrategias pedagógicas para desarrollar este aprendizaje [14], se determinan objetivos claros en cuanto a resultados de aprendizaje y, por supuesto, se hace un especial énfasis en la formación del profesorado [18]. A pesar de que es evidente la creciente aceptación y el nuevo impulso que se esta´ tomando en esta dirección, están surgiendo una serie de problemas y retos para la integración efectiva de este tipo de competencias en la enseñanza obligatoria [19]. A pesar del importante papel de las actitudes en el proceso de enseñanza-aprendizaje, estas recomendaciones no tienen en cuenta las actitudes y percepciones de alumnado ni profesorado. La investigación ha encontrado que las actitudes positivas favorecen el proceso de enseñanza-aprendizaje, tanto en estudiantes como en profesorado [10]. Así, las actitudes, intereses y percepciones favorables del alumnado hacia una materia tienden a incrementar su deseo y disfrute en el proceso de aprendizaje y su desempeño académico [11].

III. Objetivos y preguntas de investigación

Ante la urgente necesidad de incorporar el PC en el currículo educativo, parece imprescindible identificar posibles debilidades, amenazas, fortalezas y oportunidades en el sistema y en sus agentes implicados. Esta información nos permitirá determinar que´ hacer exactamente, cómo, con quién y cuándo. Por lo tanto, y con el fin de que una propuesta curricular sea adecuada a la realidad que vivimos, consideramos necesario realizar un diagnóstico del sistema educativo en base a los siguientes ejes:

1. Diagnóstico de las actitudes y la autopercepción del profesorado en el contexto del PC (que´ sensaciones, emociones o intereses percibe en relación a esta competencia). La introducción de las Ciencias de la Computación en el sistema educativo requiere de una preparación y capacitación adecuada de los docentes, así como de una predisposición positiva para la adquisición y la enseñanza de dichas competencias. En este caso, se plantea la pregunta *RQ1: ¿Tiene el profesorado una buena predisposición a desarrollar y enseñar estas habilidades?*
2. Diagnóstico de la percepción y actitudes del alumnado en cuanto a esta materia (que´ sensaciones, emociones o intereses percibe en relación a esta competencia). En este apartado tiene especial relevancia el análisis de género pues es importante identificar posibles diferencias en esta dimensión. Por lo tanto, se plantean las preguntas *RQ2: ¿Tiene el alumnado una predisposición positiva a trabajar contenidos relacionados con el PC o las Ciencias de la Computación en general?* y *RQ3: ¿Existe alguna diferencia de percepción, actitud o interés entre chicas y chicos?*

Tras realizar una breve revisión sobre las actitudes o las percepciones del alumnado y el profesorado en cuanto al PC se detectaron varios instrumentos de medición, pero ninguno que permitiera afrontar al completo las preguntas $RQ1$, $RQ2$ y $RQ3$. Por este motivo, el propósito principal de este estudio es doble. Por un lado, identificar las escalas existentes y proporcionar una breve caracterización de las mismas. En particular, se pretende recabar y presentar la información sobre (1) los contextos y muestras en los que se han aplicado, (2) sus características especificas (e.g. número de ´ítems, estructura o dimensiones del instrumento), y (3) las propiedades psicométricas y los datos de validación (si corresponde) de los instrumentos identificados. El resultado de este trabajo busca facilitar a investigadores y profesionales la elección de la herramienta de evaluación de las actitudes hacia el PC que les resulte más relevante y útil.

IV. Metodología

El marco *Preferred Reporting Items for Systematic Reviews and Meta-Analyses* (PRISMA) [20] es uno de los más utilizados a la hora de llevar a cabo una revisión sistemática del estado del arte en todas las ramas del conocimiento. El objetivo del marco PRISMA es ayudar a los autores a mejorar la información de las revisiones sistemáticas y los meta-análisis.

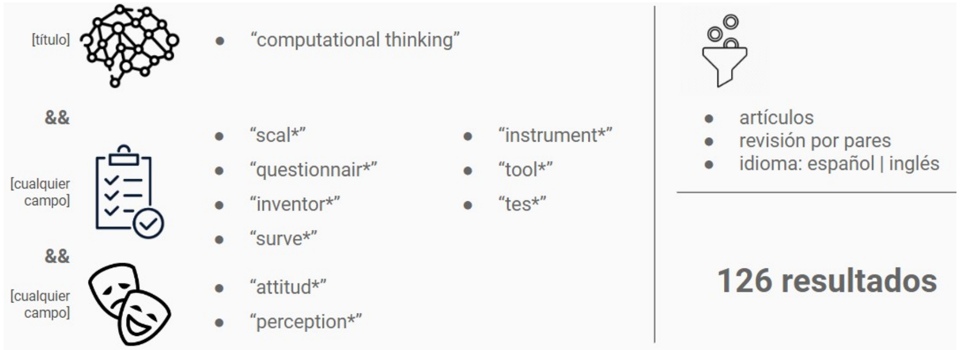


Figura 1. Parámetros de la búsqueda

A. Procedimiento de búsqueda

Para realizar la búsqueda sistemática se ha utilizado el motor de búsqueda Punto Q [1], el cual permite a los miembros de la comunidad universitaria acceder a las bases de datos, revistas, libros electrónicos y cualquier otros recursos bibliográficos que adquiere la Universidad de La Laguna. La ventaja de este metabuscador es que permite hacer búsquedas globales desde un solo punto de acceso, casi 200 recursos disponibles entre los que se encuentran bases de datos como WoS, Scopus, EBSCO, PubMed, SAGE, Dialnet, Springer, Taylor & Francis, Wiley Online, ACM Digital Library, entre otros.

Este motor de búsqueda ha sido la herramienta utilizada para llevar a cabo la búsqueda que se describe en la Figura 1. Dentro de los parámetros de búsqueda se han incluido palabras como: 'pensamiento computacional'; escala, instrumento, cuestionario, test, herramienta o estudio; actitud o percepción.

B. Criterios de selección

Para analizar sistemáticamente los trabajos detectados en el proceso de búsqueda y poder realizar una selección de los que realmente se ajustan a los objetivos de la investigación, se definieron los siguientes criterios de inclusión:

1. El estudio evalúa a estudiantes o profesores en relación al PC o algún área relacionada (Informática o Programación).
2. La evaluación se lleva a cabo en un entorno educativo formal (Educación Infantil, Educación Primaria, Educación Secundaria, Formación Profesional o Universidad).

Como criterios de exclusión se consideraron los siguientes:

1. El artículo solo evalúa habilidades, conocimientos o desempeño (y no actitudes o percepciones) del pensamiento computacional (o algún área relacionada).
2. El artículo no contiene resultados empíricos.
3. El artículo solo informa de datos de tipo cualitativo (por ejemplo, mediante preguntas abiertas).
4. El artículo no contiene información sobre la estructura del instrumento (número de dimensiones, ´ítems, descripción de factores).

[1]https://www.ull.es/servicios/biblioteca/servicios/puntoq/

C. Recogida de datos y clasificación

Los artículos obtenidos tras la búsqueda inicial fueron examinados por dos autores de forma independiente y por duplicado, siguiendo los criterios de inclusión y exclusión. Los artículos se examinaron, en primer lugar, por el titulo y el resumen y, en segundo lugar, por la lectura del texto completo. Los autores discutieron los desacuerdos y llegaron a un consenso. La extracción de datos fue realizada por dos autores de forma independiente y por duplicado, utilizando una tabla a medida desarrollada por los autores para facilitar la extracción de datos y la recopilación de la información relevante. Los resultados se compararon y se realizó´ la síntesis que se presenta a continuación.

V. RESULTADOS

Tal y como se presentó en la Figura 1, la búsqueda en PuntoQ arrojo´ una muestra inicial de 126 trabajos que encajaban con los criterios de búsqueda establecidos. Además de dichos 126 trabajos, se incluyeron 7 trabajos identificados a través de otras fuentes, obteniendo así un total de 133 artículos. Tras el primer cribado mediante la lectura del título y del resumen, se excluyeron un total de 83 artículos. A continuación, se leyó´ el texto completo de los 50 artículos restantes, tras lo que se descartaron un total de 28 trabajos. Los motivos de exclusión fueron los siguientes: el artículo no evalúa actitudes o percepciones ($n = 19$) y solo aporta resultados de tipo cualitativo ($n = 9$). Finalmente, 22 artículos cumplieron los criterios de inclusión.

En la siguiente fase, se analizaron los 22 estudios que cumplieron con los criterios de inclusión con el objetivo de examinar las dimensiones y las propiedades psicométricas de los instrumentos utilizados en dichas publicaciones. Es importante señalar que, cuando se diseñan instrumentos para medir variables psicológicas, estos instrumentos deben ser fiables y que midan el constructo que pretenden medir. Es decir, que sus mediciones estén libres de errores y que sus propiedades psicométricas sean validas. Para ello, es importante que los instrumentos cuenten con evidencia empírica de estas dos características.

La evidencia empírica de la fiabilidad habitualmente se aporta mediante el análisis de consistencia interna (por ejemplo,

Cuadro I
INSTRUMENTOS PARA EL ANÁLISIS DEL ALUMNADO

Nombre del instrumento	Referencia(s)	Idioma	País	Edad	Dimensiones	Propiedades psicométricas
Self-CT	Jun et al. (2016)	Inglés	Corea del Sur	11	Programación y comprensión de los códigos, habilidades de construcción, entusiasmo por la programación, principios de funcionamiento, aspectos de la computación	No se indica
Self-interest in programming	Jun et al. (2016); Kim et al. (2011)	Inglés	Corea del Sur	11	Interés en programación	No se indica
Attitude Scale towards Coding Education (ASTCE)	Yıldız and Seferoğlub (2021)	No se indica (probablemente Inglés/Turco)	Turquía	11	Actitud positiva general hacia la educación en codificación Actitud negativa general hacia la educación en codificación	EFA + CFA
Computer Attitude Scale (CAS)	Çakır et al. (2021)	Inglés	EE.UU.	11-15	Ansiedad hacia los ordenadores, confianza en el uso de ordenadores, gusto hacia los ordenadores, y percepción de la utilidad de los ordenadores en su futuro día a día	Fiabilidad
Kodu Game Lab - Classroom Kit 1	Chiazzese et al (2018)	Italiano (adaptación del Inglés)	Italia	9-10	Actitud hacia la programación de ordenadores y conciencia de los procesos de programación	No se indica
Pupils' Attitudes Toward Technology (PATT) survey	Olmo-Múnoz et al. (2021)	Español	España	7-8	Aspiraciones en profesiones tecnológicas, interés en la tecnología, tediosidad hacia la tecnología, consecuencias de la tecnología, la tecnología es difícil y la tecnología es para chicos y chicas	Validado
Self-efficacy questionnaire	Kjällander et al. (2021)	Sueco (adaptación del Inglés)	Sueco	6-7	Auto-eficacia (programar es divertido, programar es difícil, alguien en mi familia programa, me gustaría tener más programación en la escuela, soy bueno/a programando)	Validado
Ad hoc Questionnaire	Kazimoglu (2020)	No se indica (probablemente Inglés/ Turkish/Greek)	Cyprus	No se indica: undergraduate students	Perception on giving up their degree programs; motivation for learning computer programming; difficulty of learning computer programming; knowledge in programming constructs and their skills in CT	No se indica
Ad hoc Questionnaire	Jeom and Kim (2017)	No se indica (probablemente Inglés/ Coreano)	Corea del Sur	No se indica: estudiantes preuniversitarios	Auto-concepto de la asignatura, actitud hacia la asignatura, y hábitos de estudio para la asignatura (asignatura: curso de programación basado en PC)	Fiabilidad
Ad hoc Questionnaire	Jenson and Droumeva (2016)	Inglés	Canadá	12	Actitudes hacia el uso de ordenadores, actitudes hacia la programación y perspectiva de género en la actitud hacia los conocimientos computacionales	No se indica
Computer use and attitude survey	Wolz et al. (2011)	Inglés	EE.UU.	13-14	Actitud hacia el trabajo con ordenadores, relación entre Informática y Periodismo, creencias sobre habilidades para la programación, creencias sobre la competencia como programadores/as	No se indica
Computer Programming Attitude Scale (CPAS)	Cetin and Ozden (2015)	No se indica (probablemente Inglés/ Turco)	Turquía	No se indica: estudiantes preuniversitarios	Afecto, conocimiento y comportamiento	CFA
Ad hoc Survey	Kong et al. (2018)	No se indica (probablemente Inglés/ Chino)	China	9-12	Significado, impacto, autoeficacia creativa, autoeficacia programadora, interés por la programación y actitud hacia la colaboración en la programación	CFA
Computational Thinking Disposition Questionnaire	Jong et al. (2020)	No se indica (probablemente Inglés/ Chino)	China	10-11	Inclinación, capacidad y sensibilidad	EFA and CFA
Self-Concept and Attitudes Toward Programming (SCAPA)	Leifheit et al. (2020)	Inglés	Germany	7-10	Autoinforme de experiencia previa en programación y comprensión, autoconcepto de capacidad de programación, creencia de valor intrínseco de la programación, creencia de valor de logro de la programación, creencia de valor de utilidad de la programación, creencia de coste de la programación, y autoinforme de cumplimiento y persistencia en la programación	CFA
Computer Programming Attitude Scale for Middle School Students (CPAS-M)	Gul et al. (2021)	No se indica (probablemente Inglés/ Turco)	Turquía	10-14	Afecto, conocimiento y comportamiento	CFA

Cuadro II
INSTRUMENTOS PARA EL ANA´LISIS DEL PROFESORADO

Instrumento	Referencia	Idioma	País	Nivel educativo	Dimensiones	Propiedades psicométricas
CT Survey	Fessakis and Prantsoudi (2019)	No se indica (probablemente griego)	Grecia	Primaria, secundaria, y bachillerato	Percepciones, creencias y actitud hacia el PC, integración del PC en la educación	Fiabilidad
Interest and Attitude Questionnaire	Jaipal-Jamani1 and Angeli (2017)	Inglés	Canadá	Primaria	Interés en tecnología y robótica, interés en Ciencias y Matemáticas, procesos de resolución de problemas, trabajo colaborativo, y auto-eficacia relacionada con la robótica	Validado
Attitudes Towards Computing and CT Questionnaire	Ateşkan and Hart (2021) Adaptación de Yadav et al. (2011)	No se indica (probablemente Turco)	Turquía	Primaria y secundaria	Auto-eficacia en el uso del ordenador en clase, conocimiento de los ordenadores, satisfacción por el trabajo, resolución de problemas mediante el uso del ordenador e integración del PC en el aula	Fiabilidad
Attitudes Towards Computing and CT Questionnaire	Gleasman and Kim (2020) Adaptación de Yadav et al. (2011)	Inglés	EE.UU.	Primaria	Percepción de la computación y del PC	Validado
Computational Thinking and attitudes towards Computing	Oliveira et al. (2021) Extensión de Yadav (2014)	No se indica (probablemente Inglés/ Portugués)	Brazil	Estudiantes preuniversitarios	Definición, aula, confianza, interés y utilidad	CFA
Computing Attitude Questionnaire	Yadav et al. (2014)	Inglés	EE.UU.	Profesorado en formación	Definición, confort, interés, uso en el aula y uso en la futura carrera profesional	Fiabilidad
Technology acceptance model questionnaire	Wu et al. (2021)	Inglés	Taiwan	No se indica: estudiantes preuniversitarios	Utilidad percibida, facilidad de uso percibida, actitud hacia el uso e intenciones de comportamiento.	Fiabilidad
Learning Attitudes Questionnaire	Wu et al. (2021)	Inglés	Taiwan	No se indica: estudiantes preuniversitarios	Actitud hacia el aprendizaje	Fiabilidad

a través del índice alfa de Cronbach) o mediante el coeficiente de fiabilidad para evaluar la estabilidad de las medidas (correlación entre dos momentos de aplicación). La evidencia empírica de la validez resulta algo más compleja y cuenta con numerosos procedimientos, desde el uso de un panel de expertos/as que valoren la pertinencia de los ítems para evaluar un constructo, hasta el uso de técnicas de análisis multivariado como es el *Análisis Factorial Exploratorio* (del inglés, *Exploratory Factor Analysis* - EFA) y el *Análisis Factorial Confirmatorio* (del inglés *Confirmatory Factor Analysis* - CFA).

En los Cuadros I y II se presentan los instrumentos para la medición de percepción o actitudes hacia el PC (o áreas afines) por parte de estudiantes y profesorado, respectivamente. En los cuadros, además de incluir el nombre del instrumento, su referencia, el idioma en el que se ha elaborado, el país de aplicación y la edad o etapa educativa a la que va dirigida, incluye también las dimensiones analizadas, así como las propiedades psicométricas del instrumento.

Los 22 artículos revisados diferían en cuanto al diseño de la investigación. Solo cinco de ellos tenían como objetivo desarrollar y validar instrumentos para evaluar las actitudes hacia la programación informática en estudiantes, mientras que los demás artículos ($n = 17$) describen los efectos de una intervención/curso. En concreto, la mayoría de ellos describen un diseño cuasi-experimental, mientras que solo dos se consideran experimentos al tener un grupo de control. Los 13 diseños cuasi-experimentales incluyeron una medida pre y post-test ($n = 13$), mientras que otros evaluaron las actitudes previas al curso de PC o evaluaron las percepciones una vez finalizada la intervención. En cuanto a la fiabilidad de los instrumentos, la mayoría de los estudios han reportado evidencias como el coeficiente alfa de Cronbach. Sin embargo, en lo que respecta a la validez, solamente la mitad de los estudios identificados presentaron evidencias relacionadas específicamente con la estructura interna del test.

VI. Conclusiones

Incorporar el PC en el currículo educativo supone un salto significativo entre ser simplemente un usuario digital (cosa que hoy en día ya se presupone entre los más jóvenes) y ser un creador tecnológico. No se pretende que todas las personas seamos expertas en Informática, pero sí que interioricemos los procesos de resolución de problemas involucrados en el desarrollo de soluciones informatizadas. El beneficio de interiorizar este proceso de pensamiento es doble: por un lado, seremos capaces de analizar que´ puede ofrecernos la tecnología en nuestro ámbito personal o profesional (y el coste o la complejidad de lo que necesitamos) y, por otro lado, desarrollaremos la habilidad de resolución de problemas, fundamental para desenvolvernos satisfactoria y eficientemente en nuestro día a día.

Sin embargo, y a pesar de nuestro convencimiento de la importancia de desarrollar estas habilidades entre los más jóvenes, ¿esta´ el alumnado predispuesto a trabajar estas nuevas habilidades?, ¿tienen una buena percepción de las Ciencias de la Computación? y ¿tendrán, por tanto, una buena actitud hacia el PC, la programación y otras actividades del ámbito de la Informática? Al mismo tiempo, ¿que´ ocurre con el profesorado que tendrá que asumir la incorporación de estos nuevos contenidos en sus clases?, ¿esta´ preparado para ello o, al menos, tendrá una buena actitud hacia este cambio? Para poder obtener respuestas a estas preguntas, en este trabajo se ha presentado una revisión sistemática de la literatura, enfocada a identificar instrumentos fiables y válidos que permitan medir la percepción y/o actitud que tiene tanto el alumnado como el profesorado hacia el pensamiento computacional y otros campos relacionados.

A pesar de las limitaciones de la presente revisión sistemática, los resultados proporcionan una dirección de investigación prometedora. En concreto, los hallazgos ponen de manifiesto la carencia de instrumentos fiables y válidos que evalúen las actitudes hacia el PC en alumnado, pero especialmente en el profesorado. En este sentido, futuras líneas podrían abordar el diseño y validación de escalas para medir este tipo de actitudes en los diferentes niveles de la comunidad educativa.

Referencias

[1] D. F. Pinzón Pérez, M. Román González, and E. V. González Palacio, “El pensamiento algorítmico como estrategia didáctica para el desarrollo de habilidades de resolución de problemas en el contexto de la educación básica secundaria,” *Revista de Educación a Distancia (RED)*, vol. 23, no. 73, 2023.

[2] M. Webb, N. Davis, T. Bell, Y. Katz, N. Reynolds, D. Chambers, and M. Sysło, “Computer science in k-12 school curricula of the 2lst century: Why, what and when?,” Education and information technologies, vol. 22, pp. 445–468, Mar 2017.

[3] V. J. Shute, C. Sun, and J. Asbell-Clarke, “Demystifying computational thinking,” Educational Research Review, vol. 22, pp. 142–158, 2017.

[4] J. M. Wing, “Computational thinking,” Communications of the ACM, vol. 3, no. 39, pp. 33–35, 2006.

[5] E. Segredo, G. Miranda, and C. Leo´n, “Towards the education of the future: Computational thinking as a generative learning mechanism,” Education in the Knowledge Society, vol. 18, pp. 33–58, Jul 1, 2017.

[6] M. Román-González, J.-C. Pérez-González, and C. Jimenéz-Fernández, “Which cognitive abilities underlie computational thinking? criterion validity of the computational thinking test,” Computers in human behavior, vol. 72, pp. 678–691, 2017.

[7] R. Herrero-Álvarez, G. Miranda, C. León, and E. Segredo, “Engaging primary and secondary school students in computer science through computational thinking training,” IEEE Transactions on Emerging Topics in Computing, pp. 1–14, 05 April 2022.

[8] M. Resnick, J. Maloney, A. Monroy-Hernández, N. Rusk, E. Eastmond, K. Brennan, A. Millner, E. Rosenbaum, J. Silver, B. Silverman, and Y. Kafai, “Scratch: Programming for All,” Commun. ACM, vol. 52, pp. 60–67, Nov. 2009.

[9] Y. B. Kafai and Q. Burke, “Computer programming goes back to school,” Phi Delta Kappan, vol. 95, no. 1, pp. 61–65, 2013.

[10] J. Osborne, S. Simon, and S. Collins, “Attitudes towards science: A review of the literature and its implications,” International Journal of Science Education, vol. 25, no. 9, pp. 1049–1079, 2003.

[11] C¸ ig˘dem Yılmaz, S. A. Altun, and S. Olkun, “Factors affecting students’ attitude towards math: Abc theory and its reflection on practice,” Procedia - Social and Behavioral Sciences, vol. 2, no. 2, pp. 4502– 4506, 2010.

[12] FECYT, Google, and Everis, “Educación de las ciencias de la computación en espan˜a,” tech. rep., Fundación Española para la Ciencia y la Tecnología, 2016.

[13] J. A. Velázquez Iturbide, “Informe del grupo de trabajo SCIE/CODDII sobre la enseñanza preuniversitaria de la Informática,” tech. rep., Sociedad Científica Informática de España - Conferencia de Directores y Decanos de Ingeniería Informática, 2008.

[14] The Informatics Reference Framework for School. Informatics for All, 2022.

[15] I. N. de Tecnologías Educativas y de Formación del Profesorado, “El pensamiento computacional en la enseñanza obligatoria: Implicaciones para la política y la práctica,” tech. rep., 2017.

[16] B. O. del Estado, Ley Orgánica 3/2020, de 29 de diciembre, por la que se modifica la Ley Orgánica 2/2006, de 3 de mayo, de Educación, pp. 122868–122953. No. 340, 2020.

[17] S. Bocconi, A. Chioccariello, P. Kampylis, V. Dagiene˙, P. Wastiau, K. Engelhardt, J. Earp, M. Horvath, E. Jasute˙, C. Malagoli, V. Masiulionyte˙-Dagiene˙, G. Stupuriene˙, N. Giannoutsou, A. Inamorato dos Santos, Y. Punie, and R. Cachia, “Reviewing computational thinking in compulsory education,” tech. rep., Joint Research Centre (European Commission), Luxembourg, 2022.

[18] J. A. Velázquez Iturbide, “Informe CODDII/SCIE sobre Formación del Profesorado y Didáctica de la Informática en Etapas Preuniversitarias,” tech. rep., Conferencia de Directores y Decanos de Ingeniería Informática - Sociedad científica Informática de España, 2023.

[19] E. Commission, E. Education, and C. E. Agency, Informatics education at school in Europe. Publications Office of the European Union, 2022.

[20] Matthew J. Page et al., “The prisma 2020 statement: an updated guideline for reporting systematic reviews,” BMJ, vol. 372, 2021.

Contradictions in the adoption of Distance Education in Brazilian education during Covid-19

Cecília Cândida Frasão Vieira
Escola Nacional de Adminsitração Pública - Enap
Centro Universitário Estácio de Brasília
Brasília, Brasil
https://orcid.org/0000-0002-5359-3247

Patrícia Ramiro Silva Souza
Secretaria de Estado de Educação do Distrito Federal –SEEDF
Brasília, Brasil
https://orcid.org/0000-0003-1325-1418

Fabrício Santos Dias de Abreu
Secretaria de Estado de Educação do Distrito Federal –SEEDF
Centro Universitário Estácio de Brasília
Brasília, Brasil.
https://orcid.org/0000-0003-3055-5704

***Abstract* — This text aims to understand the contradictory relationships between the appropriation of distance education tools for use in technology-mediated education and the proposal to expand the teaching-learning process beyond content, due to the social context experienced. Factors will also be highlighted for reflection on the possibilities brought by the concepts of Distance Education (DE) and its uses in the differentiated context of social and school relations given by the sanitation situation caused by COVID-19 and, in this way, understanding that education is a process that comprises several factors for success. To this end, we will present how technology-mediated education offerings have emerged on the national scene, without a historical line or in-depth analysis, but with the aim of introducing the public to this type of teaching and the intentions behind its offer; for this, we used data from the higher education census as a didactic resource, based on the analysis carried out by Giolo (2018). Afterward, a discussion begins on the dichotomy of the proposal to teach in a different time and space, but without assuming that it is a distance learning modality. Therefore, points of weakness in education and its relationship with information and communication technologies are presented, aggravated by the situation of social isolation due to COVID-19.**

Keywords - Distance education, Technologies, Remote education, Covid-19.

.

I. Introducion

The methodologies and didactic means used in distance education have been present on the Brazilian scene since the beginning of the 20th century and have been applied by various technologies as they have been created and instituted in society's daily lives. Its purpose of providing access to knowledge needs to be analyzed in a way that is linked to the demands of society, the different social classes, and the possibilities of making use of the available technologies.

In this sense, the first topic aims to understand the contradictory relations of distance education rooted in the context of social contrast, which was entitled Reflections on technology-mediated education.

And then the second topic, non-presential education vs. distance education, aims to list factors for reflection on the possibilities of distance education based on elements that have hindered its full development and misrepresentation in the differentiated context of social and school relations given by the sanitation situation caused by COVID-19.

At the end of this text, notes are presented, which are intended to promote the investigative spirit of educators with an interest in the subject, indicating points of weakness regarding the use of technology mediation in the context of Brazilian education.

II. Reflections on technology-mediated education

In In general, distance education is more robust when it is offered by sectors other than the state and is not linked to regular basic education. According to the National Institute for Educational Studies and Research Anísio Teixeira (INEP), between 2020 and 2021, the increase in entrants to higher education courses was exclusively due to distance education being offered on the private network. During this period, the modality saw an increase of 23.3% (24.2% in private institutions), while admission to face-to-face degrees fell by 16.5%. The comparison confirms the growth trend in distance learning over time" [1]. The public, for the most part, is made up of young people and adults who require practical knowledge for a profession or are looking to complete the stages of compulsory basic education after the appropriate age for each stage has passed. An example of this is the Brazilian Universal Institute, which has been offering vocational and other courses through asynchronous learning methods since 1941.

However, this reflection must take public education as its starting point, considering that it is supported as a fundamental right for all, as advocated by Brazil's Federal Constitution. This means understanding education as a means for the development of society based on individual growth in its cognitive, emotional, and functional aspects and empowerment as a citizen with rights.

Therefore, looking at the initial projects using distance education promoted by the government, such as the Minerva Project, implemented between 1970 and 1989, technologies were used to reach the masses, in this case, radio transmissions and supplementation by correspondence, to achieve the objectives proposed by the project. These did not include improving the quality of education or the democracy of knowledge, but rather minimizing, to a certain extent, the deviation in the schooling of young people and adults. "It can be considered that the authoritarian regime saw educational projects as a way of implementing its ideas" [2]. This project was created in Brazil's history during a period of a highly authoritarian and coercive military regime, which pursued a liberal economic policy that required a workforce with minimum qualifications to operate industry, but at a low cost.

Until the 1990s, distance education continued to be inconsistent, with occasional and regional actions. Since the regulation of the Law of Guidelines and Bases of Education - LDB n. 9.394 of 1996, this modality has occupied a place in the Ministry of Education systematically, with the creation of the Secretariat for Distance Education (SEED). This now-defunct secretariat laid the formal foundations for distance education, promoting government actions that were more in line with the possibilities arising from the new means of communication and the implementation of systematized distance education in formal education. However, "there is nothing there to suggest the creation of a second type of education that would develop autonomously and in competition with face-to-face teaching" [3], but in any case, it was a step forward, given that the educational modality was authorized for all levels of schooling, with its own guidelines.

At the time of the consolidation of distance education, information and communication technologies were undergoing significant advances with the popularization of the Internet, in the same year "major portals and network connection providers were launched in Brazil and, in 1998, the country was already in 19th place in terms of the number of hosts in the world and top of the podium in South America. On the American continent, it was second only to the United States and Canada". [4].

However, the 90s saw strong neoliberal influences on the economy and major international organizations in Brazilian education, which had begun in the 80s. Melo [5] points out that the concern of the World Bank and Unesco, the mentors of educational policies in the FHC government, was that the ethical-political dimension of worker training and the training of citizens was driven "in the direction of conforming to these new needs for the multi-skilled and flexible worker, contributing to a vision of society that separates different levels of people according to their knowledge and the use they make of their power to know in the world of work".

At first, glance, mentioning the characteristics of the workers is something favorable; however, when we broaden our view of these institutions, we see that there is a movement to make use of educational possibilities as part of the market system in which more education, knowledge and schooling you acquire, the more you are valued in this competitive scenario, giving the responsibility for training development to the individual themselves and minimizing the responsibility of the public authorities to do so. This is one of the origins of the EaD brand in the 2000s, which was practically established in higher education offered by private institutions.

Giolo's study [3] systematizes data from the Higher Education Census from the 2000s onwards when distance education appeared in the statistics. Even though the first offers came from public institutions, in 2015, distance education enrollment by private initiative reached 90%. The most recent census for 2018, published in 2019, highlights that between 2008 and 2018, the number of students enrolled varied positively by 10.6% in face-to-face undergraduate courses and tripled (196.6%) in distance learning courses, and remains at over 90% with distance learning offered by private institutions.

An important thing to think about is who the students are in this 91.6%. In the technical summary of the 2017 census, the last one published so far, ", on average, entry into distance learning (at the age of 31.0) occurs later than in face-to-face learning (at the age of 24.1). It also shows that the majority are female, accounting for 55.2% of entrants, 53.9% in the face-to-face mode and 57.9% in the distance mode. In terms of academic degrees, the most common is a degree in distance learning" [6].

In the 2018 Digital Distance Learning Census, carried out by ABED on the profile of students enrolled in distance learning courses, it was shown that "this audience is already in the job market and has commitments related to their family's subsistence"[7]. This document also states that the level of knowledge has increased significantly: 88.2% of the institutions offering fully regulated distance learning courses are aware of the reasons for drop-out compared to the previous Census, although no information is provided on what these reasons might be.

However, the 2011 study carried out by ABED indicates that the causes of dropout are a lack of time and failure to adapt to the methodology. It details the student profile as mostly female, with ages ranging from 18 to 40, and also summarizes that "studying and working characterize the occupational profile of distance learning students" [8]. Giolo [3] makes a social analysis of the relationship between this profile of distance learning enrolments and the supply process, which refers to the concentration of enrolments "in degree courses, technology courses, administration, and social work as the educational market, showing the intention that has always governed the expansion of distance learning: to reach the lower classes [...]. In addition to the reduced tuition fees, the institutions offer their systems of scholarships, educational credits, and funding of various kinds. Given this, it is impossible not to deduce that distance education is producing a partition in the Brazilian education system that goes beyond the traditional partition and is more radical than this one, which has always allocated a good quality education to the rich and light and weak education to the poor. Distance education carries even more of these characteristics" [3].

Thus, considering that the applicability of the distance education modality requires specific inputs and despite using the tools en masse, there are always exclusionary processes stemming from economic power. This is also why basic education was left out of this process, "until then [1996 - LDB], only legal entities with ideal purposes, i.e. non-profit, could be involved in education. With the Provisional Measure transcribed above, for-profit entities were also able to operate in Higher Education. This explains, in part, why the private sector has made undergraduate higher education the cornerstone of its investments, leaving primary and secondary education in the doldrums. This also explains the fact that we reached 2015 with 90% of distance education enrollments controlled by the private sector" [3].

In this way, there is no way to avoid thinking about distance education, in whatever dimension, without materializing social relations and their contrasts, systematically weighing up the restriction of the lower classes' access to social rights and society's resources.

III. NON-PRESENTIAL EDUCATION VS. DISTANCE EDUCATION

Having made this general point, we now turn to distance education from a pedagogical perspective. In this sense, it is important to consider that this modality has the triad of space, time and support as the guiding principle for organizing pedagogical work. In this modality, there is a paradigmatic spectrum that school success comes from transposing the same didactics to face-to-face learning to achieve educational objectives, which needs to be questioned, because if this conception is maintained, the potential of didactic multimedia and strategies that mobilize other cognitive aspects in teaching-learning processes will not be realized.

"The centrality of knowledge in the processes of production and organization of social life breaks with the paradigm according to which education would be an instrument for "conforming" the future professional to the world of work. Discipline, obedience, and strict adherence to established rules, conditions which until then had been necessary for social inclusion via professionalization, have lost their relevance in the face of the new demands made by technological and social development" [9]. Therefore, literacy for this language is something that should be considered extremely important for the applicability of distance education.

According to Oliveira [10] "these aspects require individuals to be literate in the use of electronic instruments and to know how to produce, use, store and disseminate new forms of knowledge representation using digital language". The author goes on to say that people need to be re-educated so that, as well as using technological equipment, they can use the information and interactions inherent in current information and communication technologies, overcoming the paradigm of modern science and combining technological, human and citizen training.

The legacy of distance education is clearly in the possibilities for teaching to take place in a different time and space between teacher and student and, to this end, it has made use of the communication tools that have emerged and adapted these means to be effective. The challenge is to do this with students who are used to using existing technologies, most of the time for distraction. That said, it is considered that the interfaces suggested by distance education have a favorable space for action at the present time, in which "for the educational field, the countless possibilities of access to the global network of information through connectivity and possible interaction of subject and object (even if now no longer printed and only written) reverberates perfectly in the construction of scientific knowledge" [11].

Thinking back to the imaginative prospections of the 1970s to 1990s, embodied in science fiction films, the use of technology in everyday life was envisioned, with robots and voice commands for everything. Many of these ideas came to fruition; however, in the films, the technologies were accompanied by an evolution of society at all levels. In this way, the ideas that permeated the imagination of the youth of the 1980s, such as video calls and the possibility of communicating virtually with people from all over the world, and which are now materialized in everyday life, identify the potential of human knowledge.

This knowledge, although extensive and valuable, was not enough to prevent a virus from reaching all continents, infecting, and killing people. COVID-19, a disease caused by the coronavirus, is a novelty in the field of health. "Both this new virus and the disease it causes were unknown before the outbreak in Wuhan, China, in December 2019. Today, COVID-19 is a pandemic affecting many countries around the world" [12]. It has been identified that transmission occurs by respiratory droplets, with no vaccine, drug, or cure. The measure to minimize the damage caused by this disease has been physical distancing, i.e. "it means being physically separated. The WHO recommends keeping a distance of at least one meter from others. It is a general action that all people should take, even if they are well and have had no known exposure to COVID-19" [12].

In Brazil, "the first confirmed case of COVID-19 in Brazil continues to be the one recorded on February 26 and widely publicized by the Ministry of Health [13], but in March, there were already people with confirmed diagnoses in several Brazilian states: Alagoas, Bahia, Minas Gerais, Espírito Santo, Rio de Janeiro, São Paulo, Rio Grande do Sul and the Federal District. That same month, the "Ministry of Health regulates isolation and quarantine criteria that should be applied by health authorities to patients with suspected or confirmed coronavirus infection"[14].

Based on this situation, state governments began suspending classes at public institutions by decree and instructed private institutions to also follow the recommendations of the health authorities. At the federal level, the first action was Ordinance No. 376, of April 3, 2020, which determines art. 1 The institutions that are part of the federal education system referred to in art. 16 of Law No. 9.394, of December 20, 1996, and art. 20 of Law No. 12. 513, October 26, 2011, are hereby authorized, on an exceptional basis, about high school technical professional education courses in progress, to suspend face-to-face classes or replace them with non-face-to-face activities, for up to sixty days, which may be extended, depending on guidance from the Ministry of Health and state, municipal and district health agencies, in the form of this Ordinance.

In a sudden scenario in which face-to-face activities became unfeasible, the mediations conceived by distance education were used. Thus, technologies, which used to be seen as a means of dispersion in the classroom, are now seen as a possible means of teaching.

Regulations and announcements regarding schooling in times of social distancing use the terms non-face-to-face teaching or remote teaching. This is because distance education, in its legal conception, provides for face-to-face moments "face-to-face activities, such as tutoring, assessments, internships, professional and laboratory practices and work defense, provided for in the pedagogical or development projects of the educational institution and the course, will be carried out at the headquarters of the educational institution, at the distance education centers or in a professional environment, by the National Curriculum Guidelines" [15]

This contradiction is further exposed when the National Education Council defines non-face-to-face activities as "those to be carried out by the educational institution with students when their physical presence in the school environment is not possible"[16]. However, when detailing the strategies to be adopted for this specific teaching-learning process, it points out that "the implementation of non-face-to-face pedagogical activities is not characterized by the mere replacement of face-to-face classes, but by the use of pedagogical practices mediated or not by digital information and communication technologies that enable the development of learning objectives" [16].

In other words, the aim is to enhance the pedagogical dimension of ICTs by bringing them closer to personal relationships. Thus, the tool is chosen for its educational purpose, but, as in the past, the available solutions are sought for the resumption of academic calendars. This is in line with "the more intense use of technological means of communication and information makes teaching more complex and requires the segmentation of the act of teaching into multiple tasks, this segmentation being the main characteristic of distance learning" [17]. Later reinforced by the CNE itself, "however, despite the legal and normative possibilities of offering distance learning, it should be noted that the CNE's rules, as a rule, define distance learning as an educational modality in which didactic-pedagogical mediation, in the teaching and learning processes, occurs with the use of digital information and communication means and technologies". [16].

Even surrounded by the use of social networks, instant messaging on cell phones, and high-speed internet, given that Brazil ranks "third among countries in terms of time spent on apps, slightly above average, with 3 hours and 45 minutes"[18], technologies in educational processes are outside the public education system, in two essential instances: the first refers to the absence of a public policy for teacher training for this, and the other concerns education funding for an infrastructure that allows this.

Alongside this, we have what was discussed in the first topic of this text, which is the difference in access by social class. In Brazil, despite being one of the powerhouses in terms of the use of social networks and cell phones per inhabitant, there is a large proportion that doesn't even have access to basic sanitation, let alone information technology. The "Continuous National Household Sample Survey - Information and Communication Technology (Pnad Contínua TIC) 2018", released today (29) by the Brazilian Institute of Geography and Statistics (IBGE), shows that one in four people in Brazil do not have access to the internet. In total numbers, this represents around 46 million Brazilians who don't access the net" [19]. This is a small sample of how distant digital information is for many people, most of whom of school age attend public schools.

The Education Challenges Group posed the following question: "The change has required rapid adaptation on the part of teachers, which raises debates and questions: are teachers prepared to teach beyond the traditional format?". However, the more appropriate question would be: are teachers prepared to teach with the worsening precariousness of resources?

In order not to enter into an epistemological discussion about pedagogical trends and what traditional pedagogy is good for, it will be assumed that the intention was to portray face-to-face teaching in a formal educational environment as traditional, in this case, the school institution and the classroom. One of the gaps in teacher training is certainly the lack of consolidation of the use of digital technologies in education. It is noteworthy that in the absence of the National Curriculum Guidelines for Teacher Training "in 2015, there is a single document with DCN for all undergraduate degrees. Unlike the 2006 DCN for the Pedagogy course, distance learning is mentioned four times in the 2015 document, but only to highlight the different modalities for which the guidelines apply, equating it to other modalities such as Special Education and Field Education"[20].

The same author points out that this also occurs in the DCNs approved in December 2019. His study, which covers the National Education Conference (CONAE) of 2010 until the recent publication, in 2019, of the current National Curriculum Guidelines (DCN) for the training of Basic Education teachers, points out that "the analyses show the virtual absence of the distance modality in the legislation analyzed, contributing greatly to the advancement of the offer of teacher training courses by private companies, without considering the specificities of the modality and contributing enormously to the precariousness of training and, consequently, to the teaching career" [20].

Regarding support for teaching professionals, the CNE recommends in principle "carrying out, whenever possible, a pedagogical training process for teachers to use the methodologies, with technological mediation or not, to be employed in remote activities" [16]. However, the CNE document itself presents possibilities for the main focus on multimedia and not on pedagogical strategies, for example: "carrying out synchronous online activities by technological availability" and "offering asynchronous online activities by technological availability" [16]. Oliveira [10] highlights the importance of mediatization as an indispensable competence for the actions and conception of distance education, to ensure both technical and didactic-pedagogical quality, in the direction of breaking away from the instructional packages characteristic of industrialist models based on a linear, Cartesian, and positivist scientific discourse.

IV. Conclusion

In the first topic of this text, based on an overview of the influences under which distance education was implemented in Brazil, we realized that this modality has not moved away from the Brazilian tradition of providing good quality education for the rich and a light and weak education for the poor, as Giolo mentions, so much so that we have a student profile in higher education - the largest distance education offer in the Brazilian educational scenario - made up mainly of working women. Thus, despite enjoying technological advances, contradictorily those who experience it are those who have less access to the possibilities of using these technologies in their daily lives, providing convenience, as they still seek to meet their basic needs.

It should be noted that we have regulations that make it possible for distance learning to be offered with quality standards in both the pedagogical aspects and those related to the necessary infrastructure. However, at times when the Brazilian scenario could take on this modality as a means of minimizing educational losses as a result of the suspension of all face-to-face activities in school institutions, the term non-face-to-face teaching or remote teaching arises.

In this sense, the second topic reflects on these issues based on the guidelines issued by the National Education Council in its first opinion about the situation of social isolation caused by COVID-19.

Thus, it can be seen that the challenges are not restricted to one type of teaching or one level of education, but to education and social rights. In this sense, these considerations are intended to instigate further study of the issues addressed, as well as to contribute to reflection on professional practice itself.

Acknowledgments

Tho the Fundação de Apoio à Pesquisa do Distrito Federal – FAPDF, for its financial support. Tho Escola Nacional de Administração Pública - ENAP, The Secretaria de Estado de Educação do Distrito Federal - SEEDF e ao Centro Universitário Estácio de Brasília for their professional support

References

[1] INSTITUTO NACIONAL DE ESTUDOS E PESQUISAS EDUCACIONAIS ANÍSIO TEIXEIRA (INEP). Ensino a distância cresce 474%em uma década. Disponível em https://www.gov.br/inep/pt-br/assuntos/noticias/censo-da-educacao-superior/ensino-a-distancia-cresce-474-em-uma-decada. Acesso em 29 de agosto de 2023.

[2] MONACO, Rosa Maria Garcia. LEYENDECKER, Niely Natalino de Freitas. 'O Ensino via rádio por meio das iniciativas educativas da Universidade do Ar (1941-1945) e do projeto minerva (1970-1989)". Disponível em https://www.historiaeparcerias.rj.anpuh.org/resources/anais/11/hep2019/1562873901_ARQUIVO_07b5d2098ff3d8c30b65d29e688fa316.pdf . Acesso em 27 de agosto 2023.

[3] GIOLO, Jaime. "Educação a Distância no Brasil: a expansão vertiginosa". Disponível em https://www.seer.ufrgs.br/rbpae/article/view/82465/48878. Acesso em 09 de abril 2023.

[4] TECMUNDO. "20 anos de internet no Brasil: aonde chegamos?" https://www.tecmundo.com.br/internet/8949-20-anos-de-internet-no-brasil-aonde-chegamos-.htm . Acesso em 10 de agosto 2023.

[5] MELO, Adriano Almeida Sales. "A mundialização da educação. Consolidação do projeto neoliberal na América Latina". Disponível em http://repositorio.unicamp.br/jspui/handle/REPOSIP/253166 . Acesso em 20 agosto de 2023.

[6] INSTITUTO NACIONAL DE ESTUDOS E PESQUISAS EDUCACIONAIS ANÍSIO TEIXEIRA - INEP. "Censo do Ensino Superior - Notas Estatísticas 2018". Disponível em http://download.inep.gov.br/educacao_superior/censo_superior/documentos/2019/censo_da_educacao_superior_2018-notas_estatisticas.pdf . Acesso em 20 de agosto 2023.

[7] ASSOCIAÇÃO BRASILEIRA DE EDUCAÇÃO A DISTÂNCIA - ABED. "Censo EAD.BR: Relatório analítico da aprendizagem a distância no Brasil – 2018". Disponível em http://abed.org.br/arquivos/CENSO_DIGITAL_EAD_2018_PORTUGUES.pdf. Acesso em 09 de agosto de 2023.

[8] ASSOCIAÇÃO BRASILEIRA DE EDUCAÇÃO A DISTÂNCIA - ABED. "Censo EAD.BR: Relatório Analítico da Aprendizagem a Distância no Brasil 2012". Disponível em http://www.abed.org.br/censoead/censoEAD.BR_2012_pt.pdf.Acesso em 09 de agosto 2023.

[9] MINISTÉRIO DA EDUCAÇÃO. Parâmetros Curriculares Nacionais – Ensino Médio. Disponível em http://portal.mec.gov.br/setec/arquivos/pdf/BasesLegais.pdf. Acesso em 20 agosto 2023.

[10] OLIVEIRA, Elsa Guimarães. Educação a Distância na Transição Paradigmática. São Paulo: Papirus, 2003.

[11] MONARIN, Vitor. MACUCH, Regiane Silva. Pertinência e validação do conhecimento frente a sociedade do conhecimento. Disponível em https://revistas.ufpr.br/diver/article/view/70346/41487 . Acesso em 19 de agosto 2023.

[12] ORGANIZAÇÃO MUNDIAL DA SAÚDE - OMS. Perguntas e respostas sobre a doença por coronavírus (COVID-19). Disponível em https://www.who.int/es/emergencies/diseases/novel-coronavirus-2019/advice-for-public/q-a-coronaviruses. Acesso em 20 de agosto 2022.

[13] BRASIL. Ministério da Saúde. Primeiro caso de Covid-19 no Brasil permanece sendo o de 26 de fevereiro. Disponível em https://www.saude.gov.br/noticias/agencia-saude/47215-primeiro-caso-de-covid-19-no-brasil-permanece-sendo-o-de-26-de-fevereiro#:~:text=Desta%20forma%2C%20o%20primeiro%20caso,divulgado%20pelo%20Minist%C3%A9rio%20da%20Sa%C3%BA Acesso em 09 de agosto 2023.

[14] COEP. Linha do tempo do Coronavírus no Brasil. Disponível em http://coepbrasil.org.br/covid-linha-do-tempo-do-coronavirus-no-brasil/.. Acesso em 09 de agosto 2020

[15] BRASIL. Decreto nº 9.057, de 25 de maio de 2017. Regulamenta o art. 80 da Lei nº 9.394, de 20 de dezembro de 1996 , que estabelece as diretrizes e bases da educação nacional. Disponível em https://www.planalto.gov.br/ccivil_03/_ato2015-2018/2017/decreto/d9057.htm . Acesso em 08 de agosto 2023.

[16] CONSELHO NACIONAL DE EDUCAÇÃO - CNE. Parecer CNE/CP Nº: 5/2020 - aprovado em: 28/4/2020Disponível em http://portal.mec.gov.br/index.php?option=com_docman&view=download&alias=145011-pcp005-20&category_slug=marco-2020-pdf&Itemid=30192 . Acesso em 27 junho 2023.

[17] BELLONI, Maria Luiza. Educação a distância. 3ª ed. Campinas: Autores Associados, 2003.

[18] EMPRESA BRASILEIRA DE COMUNICAÇÃO - EBC. Brasil é o 3º país em que pessoas passam mais tempo em aplicativos. Disponível em https://agenciabrasil.ebc.com.br/geral/noticia/2020-01/brasil-e-o-3o-pais-em-que-pessoas-passam-mais-tempo-em-aplicativos . Acesso em 09 de agosto 2023.

[19] EMPRESA BRASILEIRA DE COMUNICAÇÃO - EBCb. Um em cada 4 brasileiros não tem acesso à internet, mostra pesquisa. Disponível em https://agenciabrasil.ebc.com.br/economia/noticia/2020-04/um-em-cada-quatro-brasileiros-nao-tem-acesso-internet. Acesso em 10 de agosto 2020.

[20] WILL, Daniela Erani Monteiro. OLIVEIRA, Edna Araújo dos Santos de, CERNY, Roseli Zen. A (não) presença da Educação a Distância nas políticas públicas contemporâneas para a formação inicial de docentes da Educação Básica. Disponível em http://www.seer.ufu.br/index.php/revistaeducaopoliticas/article/view/54805/28922. Acesso em 02 de agosto 2023.

Dificulades en una Experiencia de Aula Invertida con Evaluación Continua y Autorregulación

Martín Liz-Domínguez
atlanTTic Research Center
University of Vigo
Vigo, Spain
mliz@det.uvigo.es

Manuel Caeiro Rodríguez
atlanTTic Research Center
University of Vigo
Vigo, Spain
mcaeiro@det.uvigo.es

Fernando A. Mikic-Fonte
atlanTTic Research Center
University of Vigo
Vigo, Spain
mikic@det.uvigo.es

Martín Llamas-Nistal
atlanTTic Research Center
University of Vigo
Vigo, Spain
martin@det.uvigo.es

***Abstract*— Este trabajo se centra en cómo los estudiantes hacen uso de los vídeos y documentos de apoyo proporcionados en un contexto de aula invertida en la que se adopta un modelo de evaluación continua. En la experiencia descrita se hace uso de vídeos en lugar de clases magistrales, se utiliza una herramienta online que facilita la evaluación de los exámenes que se realizan en papel y también se introducen cuestiones sobre autorregulación. El trabajo realizado surge de la necesidad de prestar apoyo a los estudiantes de primer curso que se enfrentan por primera vez a la experiencia universitaria en una asignatura que tradicionalmente presenta unos niveles de fracaso y abandono significativamente altos. Los cambios introducidos están orientados a proporcionar una asistencia y un seguimiento más cercanos a los estudiantes, de forma que adopten un papel activo y puedan abordar el curso de acuerdo con una planificación detallada. Los resultados obtenidos no muestran ninguna tendencia significativa, lo que se atribuye principalmente a la falta de participación de los estudiantes en las actividades propuestas.**

Keywords—Evaluación continua, Correlación de datos, Aula invertida, Educación superior, Analítica de aprendizaje

I. Introducción

La adopción del aprendizaje en línea o e-learning ha conducido a una profunda transformación en los programas educativos tradicionales. Durante las últimas dos décadas, las instituciones de aprendizaje tradicionales, como escuelas y universidades, han ido adoptando progresivamente algunos de los aspectos que definían el aprendizaje en línea y los han integrado en sus modelos educativos junto con la instrucción supervisada tradicional en el aula. Esto significa la aparición de programas educativos que combinan ambas aproximaciones, dando lugar a un modelo conocido como aprendizaje combinado: *blended learning*.

Existen muchos tipos de metodologías de aprendizaje combinado que difieren entre sí en la forma en que combinan la instrucción en línea y presencial, y la importancia relativa que cada una de ellas tiene en el programa de aprendizaje [1]: modelos rotatorios, como el aula invertida (*flipped classroom*); modelos auto-combinados, modelos virtualmente-enriquecidos; etc.

La implementación de estas nuevas metodologías ha sido posible, en parte, gracias a la adopción generalizada de herramientas basadas en la web que brindan asistencia en el proceso educativo. Las más importantes entre ellas son los sistemas de gestión del aprendizaje (LMS), aplicaciones diseñadas para manejar recursos de aprendizaje, permitir la interacción entre los participantes en un curso o gestionar actividades de evaluación y resultados, entre otras funcionalidades. Ejemplos de plataformas LMS ampliamente utilizadas son Moodle, Blackboard o Canvas [2].

Por otra parte, tradicionalmente la educación física en general, y la educación superior en particular, han seguido un enfoque centrado en el profesor. En este enfoque, el profesor es un actor activo encargado de transmitir el conocimiento a los estudiantes a través de clases magistrales. Mientras tanto, los estudiantes son actores pasivos que toman notas y hacen preguntas. En este escenario, la responsabilidad principal del aprendizaje recae sobre el profesor. El cambio progresivo hacia enfoques centrados en el estudiante destaca una habilidad clave que los estudiantes necesitan para aprovechar al máximo sus esfuerzos de aprendizaje y optimizar su rendimiento académico: la capacidad de regular su propio proceso de aprendizaje. El concepto de aprendizaje autorregulado (SRL) ha sido estudiado por investigadores educativos durante muchas décadas, y los trabajos sobre el tema que se publicaron ya en la década de 1980 siguen siendo relevantes hasta el día de hoy [3].

En este trabajo se presenta una experiencia en la que se combina el enfoque general del aula invertida con la introducción de elementos de autorregulación. La experiencia se ha desarrollado en un curso de Arquitectura de Computadores impartido en la Universidad de Vigo (España). Este es un curso de ingeniería de primer año que generalmente involucra muchos problemas relacionados con la deserción y el fracaso. Los profesores de este curso estaban interesados en identificar a los estudiantes en riesgo lo antes posible, particularmente aquellos que con un poco de ayuda, podría potencialmente evitar suspender el curso al final del trimestre. En el artículo se muestra como se ha realizado la implementación del modelo de aula invertida con SRL en esta asignatura y se analizan algunos datos relativo a los accesos a vídeos y documentos por parte de los estudiantes, comparándolos con sus calificaciones.

El resto del documento está organizado de la siguiente manera. La sección II presenta el contexto académico. La Sección III describe los datos que fueron recogidos durante la experiencia, y la Sección IV muestra sus resultados, incluidos los resultados de correlación y agrupamiento. El documento termina con algunas conclusiones en la Sección V.

II. Contexto Académico

Los datos utilizados en este estudio corresponden a un curso de primer curso de Arquitectura de Computadores impartido en el grado de Ingeniería de Telecomunicación de la Universidad de Vigo. Más concretamente, los datos están asociados a los cursos impartidos durante los años 2020/2021 y 2021/2022, teniendo lugar entre febrero y mayo de dichos años académicos.

Hasta el curso 2017/2018, este curso se impartía durante el primer semestre, por lo que era una de las asignaturas que los estudiantes debían cursar justo después de entrar en el grado. A partir del año académico 2018/2019, la arquitectura de computadoras se imparte en el segundo semestre, a partir de finales de enero o principios de febrero y terminando en mayo, abarcando un período de 16 semanas.

Históricamente, la Arquitectura de Computadores ha sido una asignatura difícil de aprobar para los estudiantes. La Tabla I resume las estadísticas de rendimiento de los estudiantes de la asignatura en los últimos cursos académicos, según los indicadores públicos de la Universidad de Vigo [4]. En general, la proporción de estudiantes matriculados que aprobaron el curso osciló entre el 27% y el 42%, dependiendo del año académico, que generalmente estaban muy por debajo de las tasas de aprobados promedio para las asignaturas de primer año en el grado, que se sitúa entre el 40% y el 47%.

TABLE III. ESTADÍSTICAS DE RESULTADOS DE LA ASIGNATURA

Curso académico	Porcentaje de abandonos	Porcentaje de aprobados	Porcentaje de aprobados (excl. Abandonos)
2015/2016	20.9	31.1	39.3
2016/2017	14.5	37.2	43.6
2017/2018	15.8	41.9	49.8
2018/2019	18.1	31.5	38.4
2019/2020	14.9	27.9	32.8
2020/2021	24.0	31.9	42.0
2021/2022	28.4	27.4	38.4

La asignatura se divide en dos partes: teoría y laboratorio. La parte teórica cubre los principales conocimientos que los estudiantes necesitan adquirir para completar la asignatura, incluyendo temas como modelos informáticos básicos, representación numérica en ordenadores, instrucciones de montaje o conceptos básicos de sistemas operativos. Durante las sesiones de laboratorio, los estudiantes necesitan resolver tareas de programación utilizando lenguaje ensamblador. Estas tareas se vuelven cada vez más complejas a medida que avanza el curso, comenzando con programas básicos con operaciones aritméticas y de entrada/salida simples, y eventualmente implementando conceptos más avanzados como el uso de subrutinas o memoria basada en pilas.

En cuanto a la evaluación, tanto la teoría como el laboratorio ofrecen dos opciones: evaluación continua y evaluación final. En la evaluación continua, las calificaciones de los estudiantes se calculan en función de las puntuaciones obtenidas en varios exámenes realizados a lo largo del curso. Por su parte, las calificaciones de los alumnos que optan por el sistema de evaluación final dependen exclusivamente del resultado obtenido en un único examen al finalizar el curso. Normalmente, la mayoría de los estudiantes eligen ser evaluados utilizando la opción de evaluación continua. En la parte de laboratorio, los estudiantes que optan por el sistema de evaluación continua realizan un total de tres exámenes. Sin embargo, el número de exámenes de evaluación continua realizados en la parte de teoría ha cambiado a lo largo de los años. En los años académicos hasta 2018/2019, los estudiantes realizaron exámenes cortos cada semana, cubriendo en cada uno de ellos los contenidos del curso hasta ese momento, para un total de aproximadamente 12 exámenes en el semestre. A partir de 2019/2020, el número de exámenes se redujo a 6, realizados cada dos o tres semanas.

A partir del curso 2017/2018, se implementó un enfoque de clase invertida o flipped classroom en la parte teórica de la asignatura. Esto significa que las clases que se impartían en la modalidad de clase magistral se proporcionaron en forma de vídeo para que los estudiantes las vieran en casa antes de la sesión semanal en el aula, que a su vez se utilizaba para resolver problemas prácticos, responder preguntas y realizar los exámenes de evaluación continua [5].

Los estudios incluidos en este artículo se centran en los cursos de Arquitectura de Computadores correspondientes a los cursos 2020/2021 y 2021/2022. Durante estos años, la asignatura implementó el modelo de evaluación continua, introducido en 2019/2020. Sin embargo, los datos del año académico 2019/2020 se evitan porque el curso se vio interrumpido por la pandemia de COVID-19, lo que imposibilitó continuar con el sistema de aula invertida y, en general, cambió el contexto educativo hasta el punto de que no se pudo comparar razonablemente con los dos años académicos más recientes [6].

La Tabla II resume las estadísticas de matrícula para el curso de Arquitectura de Computadores en los años académicos 2020/2021 y 2021/2022, según lo observado en el LMS institucional.

TABLE IV. RESUMEN DE LAS CARACTERÍSTICAS POBLACIONABLES

Parámetro	2020/2021	2021/2022
Estudiantes totales	198	204
Estudiantes activos	186 (94%)	187 (92%)
Estudiantes totales de primer año	114	126
Estudiantes de primer año que aprueban en primera oportunidad	28 (22%)	17 (13%)
Estudiantes de primer año que abandonan (no realizan ningún examen)	34 (29%)	42 (33%)
Estudiantes de primer año inactivos (sin interacciones en Moodle)	6 (5%)	13 (10%)
Tamaño del registro (número de eventos)	51.461	51.481
Inicio del registro (primer día de curso)	2021/02/08	2022/01/31
Fin del registro	2021/05/30	2022/05/22

La implementación de la evaluación continua en el curso 2020/2021 implicó la realización de un total de 6 exámenes durante las 15 semanas que duró el curso. Por lo tanto, se realizó un examen cada dos o tres semanas, cubriendo en cada uno de ellos los contenidos del curso hasta la fecha del examen. En este artículo, el período de varias semanas que termina con un examen de evaluación continua se denomina parte. La Tabla III enumera las partes de las seis divisiones, incluidas las fechas exactas de inicio y finalización durante el curso 2020/2021. Como se puede observar, no todas las partes son igualmente largas, siendo la primera división particularmente más larga que las otras debido al momento de algunas vacaciones en el calendario académico.

En cuanto a los vídeos de flipped classroom, se considera que cada uno de ellos pertenece a una parte específica, dependiendo de la semana en la que se publica el vídeo y durante la cual se supone que los estudiantes deben verlo. La Tabla III contiene la información sobre el número de vídeos que pertenecen a cada parte. En total se publicaron 75 vídeos a lo largo del curso. Cada parte tenía al menos 10 vídeos asociados, con la excepción del tercero, que se centró principalmente en resolver ejercicios prácticos y no introdujo tanto contenido nuevo como las otras.

TABLE V. DISTRIBUCIÓN DE VÍDEOS A LO LARGO DE LAS PARTES EN LAS QUE SE DIVIDIÓ EL CURSO PARA EL AÑO ACADÉMICO 2020/2021

Parte	Inicio	Fin	Duración	Vídeos
1	1 febrero	1 marzo	4 semanas	18
2	2 marzo	15 marzo	2 semanas	12
3	16 marzo	5 abril	3 semanas	5
4	6 de abril	19 abril	2 semanas	14
5	20 de abril	3 mayo	2 semanas	15
6	4 de mayo	17 mayo	2 semanas	11

III. Herramientas Utilizadas

Para la realización de este y otros trabajos relativos al estudio de la asignatura en los cursos 2020/2021 y 2021/2022 [5-8] se han utilizado tres herramientas principales: Moodle LMS; la plataforma de evaluación electrónica BeA; y cuestionarios de SRL autoreportados.

A. *Moodle*

A partir del curso 2020/2021, la Universidad de Vigo lanzó Moovi, su nuevo LMS institucional basado en la nube basado en Moodle 3.9. Esta plataforma reemplazó a Faitic, un LMS administrado localmente que había estado activo durante casi 20 años.

El enfoque de aula invertida adoptado en el curso de Arquitectura de Computadores requirió un uso extensivo de la plataforma Moovi. Específicamente, el LMS se utilizó para los siguientes propósitos:

- Subir las vídeoconferencias que cubren contenidos teóricos, así como material complementario como diapositivas o resúmenes.
- Publicar anuncios dirigidos a todos los estudiantes para comunicar información importante sobre el tema.
- Organizar foros de discusión para que los estudiantes hagan preguntas sobre el contenido del curso.
- Creación de pruebas de autoevaluación que los estudiantes pueden realizar opcionalmente para evaluar sus conocimientos.
- Cargar las tareas de programación que los estudiantes necesitan realizar en las sesiones de laboratorio.
- Llevar un libro de calificaciones donde los estudiantes puedan ver sus resultados en las pruebas de autoevaluación y las calificaciones obtenidas en los exámenes de laboratorio.

Moodle registra todas las acciones que sus usuarios realizan en la plataforma, como iniciar sesión en el curso de Arquitectura de Computadores, acceder a recursos o realizar pruebas de autoevaluación. Estos registros pueden ser vistos y exportados por usuarios privilegiados, como profesores o administradores del sistema. La figura 1 muestra cómo se muestran los registros de actividad dentro de la plataforma. Los registros de Moovi son una fuente clave de datos que pueden ser analizados a partir de ficheros de datos en formatos abiertos como CSV.

25 de Agosto de 2022, 17:55		-	Proba: Prueba de primera semana	Proba	Módulo do curso consultado	The user with id '46523' viewed the 'quiz' activity with course module id '314985'.
25 de Agosto de 2022, 17:55			Curso: 2122-V05G301V01109 Informática: Arquitectura de ordenadores	Sistema	Informe de usuario do curso consultado	The user with id '46523' viewed the user report for the course with id '7349' for user with id '46523'.
25 de Agosto de 2022, 00:59		-	Curso: 2122-V05G301V01109 Informática: Arquitectura de ordenadores	Sistema	Curso consultado	The user with id '48200' viewed the course with id '7349'.
24 de Agosto de 2022, 16:00		-	Curso: 2122-V05G301V01109 Informática: Arquitectura de ordenadores	Sistema	Curso consultado	The user with id '13388' viewed the course with id '7349'.

Fig. 1. Captura del registro de Moodle en la asignatura de Arquitectura de Ordenadores (los nombres de los estudiantes han sido difuminados).

B. *BeA*

Los exámenes de evaluación continua no se manejan a través de Moovi. En su lugar, la herramienta de evaluación electrónica Blended E-Assessment (BeA). Esta es una plataforma que proporciona una forma de evaluar y revisar los exámenes tradicionales en papel en un entorno en línea. Fue desarrollada en el grupo de investigación de Ingeniería de Sistemas Telemáticos de AtlanTTic (Universidad de Vigo), y se ha utilizado en el curso de Arquitectura de Computadores desde el año 2010 [9].

La figura 2 muestra una captura de pantalla de la característica más importante de BeA: la evaluación en línea de los exámenes en papel. Antes de que los exámenes se impriman y realicen en el aula, el profesor carga una plantilla y define la ubicación de cada área de preguntas y respuestas en el examen. Después de realizar los exámenes, el profesor los escanea y los vuelve a cargar en BeA, que recorta automáticamente las respuestas de los estudiantes y proporciona una interfaz intuitiva para su evaluación. Desde la perspectiva del profesor, esta es una forma más rápida y consistente de calificar una gran cantidad de exámenes, ya que las respuestas a los mismos errores se pueden reutilizar para varios estudiantes. Además, una vez que se completa la evaluación, los estudiantes pueden ver sus exámenes calificados directamente en BeA, sin la necesidad de programar una cita en persona con el maestro.

A lo largo de los años, BeA se ha actualizado con nuevas características, tales como:

- Asignación automática de plazas en el aula a los alumnos, con el fin de agilizar la fase de configuración del examen.
- Exámenes de tipo opción múltiple que son calificados automáticamente por la plataforma [10].
- La opción de que los estudiantes carguen imágenes de sus respuestas a BeA, en lugar de que el profesor las escanee [11].
- La posibilidad de definir cuestionarios o encuestas con preguntas de opción múltiple para que los estudiantes las realicen a través de la plataforma.
- La posibilidad realizar juegos tipo cuestionario en el aula, similar a herramientas como Kahoot! [12].

Desde una perspectiva de minería de datos, BeA brinda la oportunidad de recopilar algunos tipos de datos relacionados con la evaluación que de otro modo serían difíciles de obtener. Los tipos de datos que se pueden recuperar de BeA incluyen:

- Puntuaciones obtenidas por los estudiantes en exámenes y en preguntas individuales.
- Marcas de tiempo de los inicios de sesión de los estudiantes en la plataforma.

- Marcas de tiempo de los accesos de los estudiantes a las evaluaciones de los exámenes.
- Tipos de errores cometidos por los estudiantes en las preguntas del examen.
- Mensajes intercambiados entre estudiantes y profesores en revisiones de exámenes.
- Respuestas de los estudiantes en encuestas y juegos de preguntas.

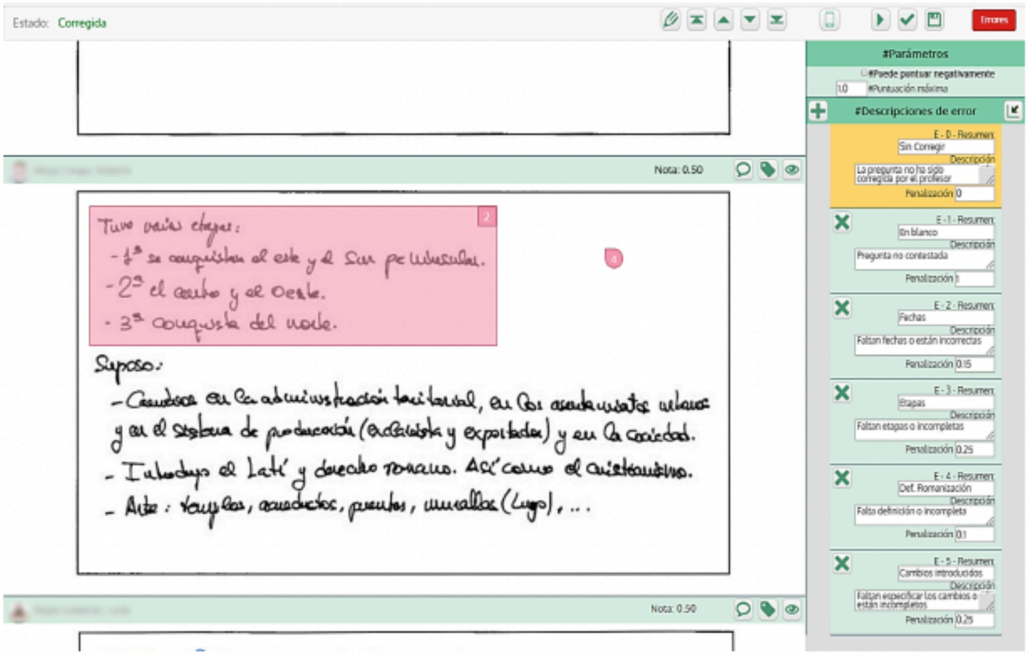


Fig. 2. Captura de la interfaz de BEA para la corrección de exámenes. En el lado derecho se pueden ver varios tipos de errores introducidos por el profesor, los cuales pueden ser reutilizados a lo largo de la evaluación de distintos estudiantes.

C. Cuestionarios sobre autorregulación

Los datos obtenidos directamente de los registros de las plataformas en línea, ya sea Moodle o BeA, se consideran datos de tipo observacional: representan objetivamente las acciones que los estudiantes realizan en cada plataforma. Sin embargo, hay algunos aspectos del proceso de aprendizaje de los estudiantes que son muy difíciles, si no imposibles, de inferir basándose solo en este tipo de datos. En algunos casos, puede valer la pena complementar los registros de LMS con datos obtenidos directamente de los estudiantes, también conocidos como datos autoreportados. Estos datos comprenden información subjetiva que los estudiantes proporcionan como respuestas a instrumentos como encuestas o cuestionarios.

Los investigadores suelen recurrir al uso de cuestionarios para identificar las fortalezas y debilidades de los estudiantes con respecto al aprendizaje autorregulado. Las principales ventajas de usar cuestionarios son que son relativamente fáciles de diseñar y administrar, y la interpretación de los resultados suele ser más simple que la comprensión de los resultados del análisis de los datos observacionales. Por otro lado, la naturaleza subjetiva de las respuestas al cuestionario puede hacerlas menos confiables que los datos de observación, ya que los estudiantes pueden proporcionar respuestas engañosas intencionalmente o no [13].

En los cursos 2020/2021 y 2021/2022 se diseñaron una serie de cuestionarios SRL para que los estudiantes de Arquitectura de Computadores respondieran a lo largo del curso. Las preguntas incluidas fueron seleccionadas y adaptadas de los cuestionarios SRL existentes en la literatura, y cada pregunta estaba destinada a asociarse con una categoría específica de SRL.

Los ítems de los cuestionarios SRL no eran técnicamente preguntas, sino más bien declaraciones a las que los estudiantes necesitaban declarar su nivel de acuerdo. Cada ítem fue respondido usando una escala Likert de cinco niveles, que van desde "completamente en desacuerdo" a "completamente de acuerdo". Responder a los cuestionarios SRL no era una actividad obligatoria para los estudiantes, y no se tuvieron en cuenta en términos de puntuación del curso.

Aunque el propósito detrás de la realización de estos cuestionarios SRL fue el mismo en ambos años académicos, hubo diferencias en la forma en que se organizaron y llevaron a cabo. Los cuestionarios SRL realizados en el curso 2020/2021 se estructuraron de la siguiente manera:

- Un cuestionario de 20 ítems realizado al comienzo del curso, en su segunda semana. Este cuestionario se realizó durante una sesión en el aula. Originalmente, la idea era realizarlo en papel y luego escanear las respuestas usando BeA. Sin embargo, un pico de casos de COVID-19 justo al comienzo del curso obligó a las clases a impartirse en línea durante las primeras dos semanas. Por lo tanto, el cuestionario se realizó utilizando el módulo de encuesta en Moovi en su lugar.
- Tres cuestionarios más cortos de 7 ítems, realizados durante las semanas 5, 9 y 13 del curso. Estos no se realizaron en el aula, sino que el módulo de encuesta BeA, que se desarrolló recientemente en ese momento, se utilizó para que los estudiantes las respondieran en casa.

En general, se utilizaron un total de 41 ítems del cuestionario SRL durante el año académico 2020/2021.

El principal problema con este enfoque fue que el número de estudiantes que respondieron los cuestionarios fue muy bajo, aparte del primero realizado durante una sesión en el aula. Como esta era una actividad opcional, la mayoría de los estudiantes optaron por no responderlas en su propio tiempo. La columna 2020/2021 de la Tabla IV muestra la enorme brecha de participación entre el primer cuestionario y los siguientes.

TABLE VI. ESTUDIANTES QUE RESPONDIERON CUESTIONARIOS DE AUTORREGULACIÓN

NÚMERO DE CUESTIONARIO	2020/2021		2021/2022	
	Semana	# Estud.	Semana	# Estud.
1 (en el aula)	2	113	2	100
2	5	22	4	60
3	9	22	7	57
4	13	17	9	37
5	No aplicable		13	44
6	No aplicable		15	55

Con el fin de mitigar el problema de la baja participación de los estudiantes, todos los cuestionarios en el año académico 2021/2022 se realizaron durante las sesiones presenciales. El primer cuestionario siguió el mismo formato que su contraparte en el año académico anterior: un cuestionario de 20 ítems realizado en papel en el aula. Mientras tanto, todos los cuestionarios posteriores se llevaron a cabo con la ayuda de una función BeA recientemente desarrollada: la posibilidad de realizar cuestionarios durante las sesiones en el aula [12]. Esta característica es similar en concepto y funcionalidad a la de Kahoot!, una popular herramienta de gamificación utilizada en muchos tipos de cursos y en todos los niveles académicos.

Durante las sesiones en el aula en la curso 2021/2022 de "Arquitectura de computadoras", los cuestionarios de BeA se realizaron como una forma gamificada para que los estudiantes revisaran algunos de los conceptos estudiados a lo largo de la semana. Entre el conjunto de preguntas del cuestionario, se introdujeron algunos ítems del cuestionario SRL, configurados de tal manera que sus respuestas no impactaran en el puntaje final obtenido en el cuestionario.

El motivo principal para llevar a cabo los cuestionarios SRL de esta manera fue vincular el número de respuestas a la asistencia a clase y ser lo menos intrusivo posible. Sin embargo, la desventaja de este enfoque fue que requería el uso de algún tiempo de sesión en el aula, que puede ser bastante limitado para comenzar en un curso como "Arquitectura de computadoras". A menudo, el profesor no podía permitirse dedicar un gran segmento de una sola sesión a llevar a cabo un largo cuestionario SRL. Esto podría remediarse parcialmente realizando un mayor número de cuestionarios más cortos a lo largo del curso, pero aún existía una compensación entre la participación de los estudiantes y el número total de elementos del cuestionario.

Con este cambio de procedimiento, la estructura de los cuestionarios SRL durante el año académico 2021/2022 fue la siguiente:

- Un cuestionario de 20 ítems realizado al inicio del curso, en su segunda semana. Este cuestionario se realizó en papel durante una sesión en el aula.
- Cinco cuestionarios de 2 ítems, realizados durante las semanas 4, 7, 9, 13 y 15 del curso.

Por lo tanto, se utilizaron un total de 30 ítems del cuestionario durante el año académico 2021/2022. Si bien estos son 11 ítems menos que en el año académico anterior, la participación de los estudiantes fue significativamente mayor en general. Como se muestra en la Tabla IV, el número de estudiantes que respondieron cuestionarios SRL en el año académico 2021/2022 duplicó, o incluso triplicó, las cifras observadas en 2020/2021.

IV. RESULTADOS

En esta sección se muestran algunos resultados que no se han mostrado en trabajos publicados anteriormente [5-8] sobre los estudiantes de los cursos 2021/2022.

D. *Estadísticas de resultados*

La Tabla V muestra las estadísticas de aprobados, suspensos y no presentados en los cursos 2020/2021 y 2021/2022. Como se puede ver los resultados presentan bastantes variaciones, aunque el número de no presentados es muy similar en ambos cursos académicos.

TABLE VII. ESTUDIANTES QUE ACCEDIERON A VÍDEOS O DOCUMENTOS AL MENOS UNA VEZ

Curso	Estudiantes	Aprobados	Suspensos	No presentados
2020/2021	163	56 (34.4%)	80 (49.1%)	27 (16.5%)
2021/2022	166	39 (23.5%)	98 (59.0%)	29 (17.5%)
Total	329	95 (28.9%)	178 (54.1%)	56 (17.0%)

E. *Visualización de Accesos a Vídeos*

La Figura 3 representa la distribución de los accesos a vídeos y documentos por parte de los estudiantes en cada año académico. Cada diagrama de caja se produce considerando la cantidad de veces que cada estudiante hizo clic en un vídeo o en un documento. Se puede ver como en ambos cursos académicos hay una tendencia clara a acceder a más vídeos que documentos. Ahora bien, se debe tener en cuenta que los documentos pueden ser descargados localmente y vistos en por los estudiantes en otras ocasiones, mientras que los vídeos sólo pueden ser visualizados online.

F. *Correlación entre calificación final, acceso a vídeos y documentos*

La Figura 4 muestra una tabla de correlación entre la calificación final obtenida por los estudiantes y sus accesos a vídeos y a documentos. Como puede comprobarse no hay ninguna correlación significativa. Sólo en el caso de accesos a vídeos y documentos se encuentra una correlación que podríamos considerar como interesante, del 71%, aunque por otra parte es lo que podríamos esperar. Los estudiantes que ven más vídeos también ven más documentos.

G. *Clustering de los Estudiantes*

Considerando la correlación entre accesos a vídeos y a documentos, se ha realizado un análisis del clustering de los estudiantes. Los resultados mostrados en la figura 5 distinguen 4 agrupaciones de estudiantes, que van en orden creciente en función del número de vídeos visualizados. En cuanto a los accesos a documentos no se observan distinciones claras entre las 4 agrupaciones, aunque por el efecto de la correlación existente si se observa un incremento en el número de documentos para cada clúster.

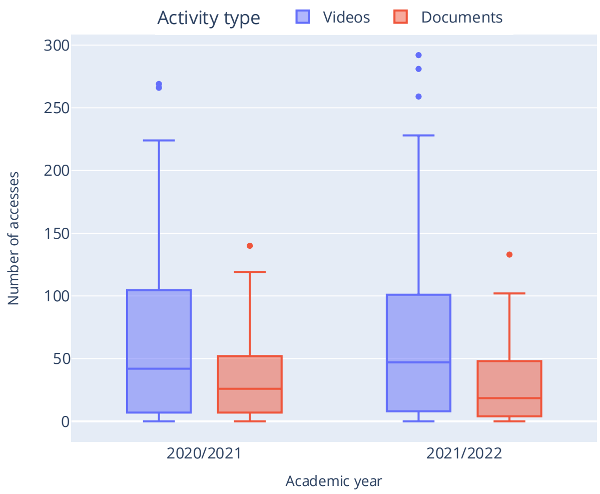


Fig. 3. Diagrama de cajas mostrando volumen de accesos a vídeos y a documentos.

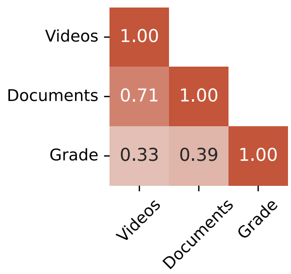


Fig. 4. Correlación de estudiantes en función de su calificación final, accesos a documentos y a vídeos.

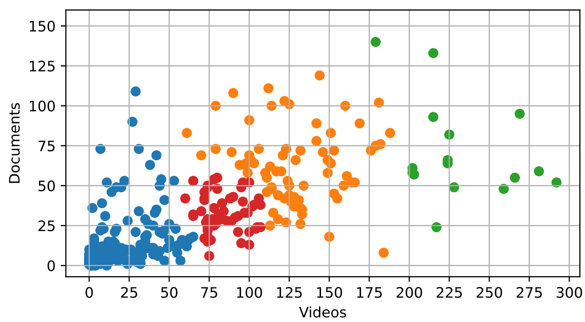


Fig. 5. Identificación de agrupaciones de estudiantes en función de sus accesos a documentos y a vídeos.

V. Conclusiones

En trabajos publicados anteriormente hemos presentado algunos resultados interesantes sobre la actividad de los estudiantes en el contexto de la experiencia de aula invertida con evaluación continua y autorregulación. Sin embargo, los resultados mostrados en este artículo sobre los accesos a vídeos y documentos no ofrecen ninguna tendencia o indicador relevante. Quizás lo que más se puede destacar de la experiencia es la falta de participación de los estudiantes, que a pesar de contar con una planificación detallada y ordenada, no se involucran en las actividades planteadas: las visualizaciones de vídeos y de documentos son bajas y no participan en los cuestionarios de autorregulación.

Quizás la principal conclusión de esta experiencia sea la dificultad para organizar de forma detallada una aproximación como la mostrada y mantenerla sin modificaciones ni cambios a lo largo del tiempo. Como se ha descrito, la asignatura ha sufrido numerosos cambios en los últimos años, aunque el contenido de la misma no ha cambiado, pero si las condiciones de contexto, sobre todo derivados del COVID. Este escenario cambiante supone un hándicap muy importante de cara a la realización de estudios sobre los estudiantes y su evolución, dificultando la realización de comparativas entre distintos cursos. Es necesario considerar experiencias más estables para de esa forma poder comparar el efecto de cambios específicos.

Referencias

[1] Staker, H., Horn, M.B.: Classifying K-12 Blended Learning. Tech. rep., Innosight Institute (may 2012), http://files.eric.ed.gov/fulltext/ED535180.pdf

[2] Mohd Kasim, N.N., Khalid, F.: Choosing the Right Learning Management System (LMS) for the Higher Education Institution Context: A Systematic Review. International Journal of Emerging Technologies in Learning (iJET) 11(06), 55 (jun 2016)

[3] Zimmerman, B.J.: Becoming a self-regulated learner: Which are the key subprocesses? Contemporary Educational Psychology 11(4), 307–313 (oct 1986)

[4] Transparency Portal - University of Vigo: 4.1. Estudos de grao, 1. e 2. ciclo, e máster, https://secretaria.uvigo.gal/uv/web/transparencia/grupo/show/5/51

[5] Llamas-Nistal, M., Mikic-Fonte, F.A., Caeiro-Rodriguez, M., Liz-Dominguez, M.: Supporting Intensive Continuous Assessment With BeA in a Flipped Classroom Experience. IEEE Access 7, 150022–150036 (2019)

[6] Llamas-Nistal, M., Mikic-Fonte, F.A., Caeiro-Rodriguez, M., Liz-Dominguez, M.: Teaching during the COVID-19 pandemic as an opportunity to change the education of the future. In: 2021 International Symposium on Computers in Education (SIIE)

[7] Liz-Domínguez, M., Caeiro-Rodríguez, M., Llamas-Nistal, M., Mikic-Fonte, F.: Exploring the Synergies between Gamification and Data Collection in Higher Education. In: Learning Analytics Summer Institute Spain 2022: Learning Analytics: Here to Stay. CEUR-WS, Salamanca, Spain (2022)

[8] Liz-Domínguez, M., Llamas-Nistal, M., Caeiro-Rodríguez, M., Mikic-Fonte, F.A.: Profiling Students' Self-Regulation With Learning Analytics: A Proof of Concept. IEEE Access 10, 71899-71913 (2022)

[9] Llamas-Nistal, M., Fernández-Iglesias, M.J., González-Tato, J., Mikic-Fonte, F.A.: Blended e-assessment: Migrating classical exams to the digital world. Computers & Education 62, 72–87 (mar 2013)

[10] Llamas Nistal, M., Mikic Fonte, F.A., Caeiro Rodríguez, M., Queipo Pardo, A., Liz Domínguez, M.: BeA add-ons to support on-line assessment and to improve review communications. The International Journal of Engineering Education 33(2), 898–907 (2017)

[11] Llamas-Nistal, M., Mikic-Fonte, F.A., Caeiro-Rodriguez, M., Liz-Dominguez, M.: BeA (Blended e-Assessment): adapting to the COVID-19 world. In: 2021 IEEE Global Engineering Education Conference (EDUCON). vol. 2021-April, pp. 1532– 1536. IEEE (apr 2021)

[12] Mikic-Fonte, F., Llamas-Nistal, M., Caeiro-Rodriguez, M., Liz-Dominguez, M.: A Gamification Module for BeA Platform. In: 2020 IEEE Frontiers in Education Conference (FIE). vol. 2020-Octob, pp. 1–5. IEEE (oct 2020)

[13] Winne, P.H., Perry, N.E.: Measuring Self-Regulated Learning. In: Handbook of Self-Regulation, pp. 531–566. Elsevier, San Diego (jan 2000)

JOGOS EDUCATIVOS DIGITAIS PARA APRENDER MATEMÁTICA

Digital Educational Games for learning mathematics

Catarina Delgado
Escola Superior de Educação
Instituto Politécnico de Setúbal
Setúbal, Portugal
catarina.delgado@ese.ips.pt

Fátima Mendes
Escola Superior de Educação
Instituto Politécnico de Setúbal
Setúbal, Portugal
fatima.mendes@ese.ips.pt

***Resumo*—Este artigo tem como objetivos apresentar e discutir: i) as potencialidades de jogos educativos digitais de matemática na aprendizagem de tópicos essenciais do currículo do ensino básico e ii) as perceções dos alunos e dos professores que validaram os jogos. Participaram no estudo 397 alunos e 20 professores. Os dados foram recolhidos através de observação direta da sala de aula, inquéritos e entrevistas com professores e alunos. Os resultados do estudo mostram que houve uma melhoria no desempenho matemático dos alunos nos pós-testes. Tanto os alunos como os professores têm uma perceção muito positiva sobre os jogos.**

***Abstract*—This paper aims to present and discuss: i) the potential of mathematics digital educational games in learning of essential topics of the curriculum of the of elementary school and ii) the perceptions about of the students and the teachers that validated the games. A total of 397 pupils and 20 teachers participated in the study. Data were collected through direct classroom observation, surveys and interviews with both teachers and students. the results of the study show that there was an improvement in the mathematical performance of the students in the post-tests. Both students and teachers have a very positive perceptions about the games.**

Palavras-chave—jogos educativos digitais, aprendizagem da matemática; design de jogos educativos digitais

Keywords—Digital educational games, mathematics learning, digital educational game design

I. INTRODUÇÃO

A ideia de que todos devem aprender Matemática é consensual, sendo assumido que todas as crianças devem ter uma experiência matemática adequada e suficientemente rica e desafiadora, que lhes permita desenvolver a literacia matemática. De acordo com a OCDE (Organização para a Cooperação e Desenvolvimento Económico), esta é entendida como a capacidade de raciocinar matematicamente e interpretar e usar a Matemática na resolução de problemas de contextos diversos do mundo real [1]. Embora a escola tenha um papel crucial na aprendizagem da matemática, é certo que atualmente existem recursos que podem ser utilizados autonomamente pelas crianças e que promovem o desenvolvimento de competências matemáticas.

Com a finalidade de construir recursos educativos digitais de acesso livre, que promovessem a literacia matemática de alunos do 1.º ciclo e que pudessem ser utilizados autonomamente, um grupo de docentes desta área disciplinar participou no Projeto Recursos Educativos Digitais (RED) desenvolvido pela Direção Geral da Educação (DGE) em parceria com a Universidade Nova de Lisboa – iNOVA Media Lab, a Faculdade de Letras da Universidade de Lisboa, o Instituto Politécnico de Setúbal e a Universidade de Aveiro. Este projeto, de âmbito mais amplo, teve como finalidade conceber, produzir, disponibilizar e divulgar recursos educativos digitais interativos, de acesso livre e validados científica e pedagogicamente, para as áreas curriculares de Ciências Experimentais, Matemática e Português, do 1.º ciclo do ensino básico, disponíveis em https://redge.dge.mec.pt/site/node/4.

Este artigo tem como objetivo apresentar e discutir as potencialidades dos jogos educativos digitais de matemática, que visam apoiar a aprendizagem da Matemática em tópicos essenciais do currículo do 1.º ciclo do ensino básico, e que foram construídos por um grupo de docentes: Joana Brocardo e Lurdes Serrazina (coordenadoras da área de Matemática), Ana Maria Boavida, Catarina Delgado, Fátima Mendes e Margarida Rodrigues. Este texto analisa, ainda, as perceções dos alunos e das professoras do 1.º ciclo do ensino básico, que validaram os jogos, sobre as suas potencialidades e, em particular, no que respeita à aprendizagem da matemática.

II. JOGOS EDUCATIVOS DIGITAIS NA APRENDIZAGEM (DA MATEMÁTICA)

Nas últimas duas décadas, a digitalização tem vindo a influenciar a estrutura educacional, constituindo um foco de atenção importante para profissionais da educação, de investigadores e de decisores ao nível do desenvolvimento de políticas educativas [2]. Recentemente, a União Europeia (UE) propôs um plano de ação para a educação digital que reflete a política educacional da UE e estabelece uma visão comum sobre as ações para promover uma educação digital inclusiva e acessível de alta qualidade na Europa [3]. Este plano tem como objetivo apoiar a adaptação dos sistemas de educação e formação dos Estados-Membros à era digital. Entre outros aspetos, enfatiza a necessidade de garantir o desenvolvimento das competências digitais dos alunos.

Em Portugal, uma recomendação do Conselho Nacional de Educação aponta para a necessidade de "avaliar como ferramentas, estratégias pedagógicas e ambientes de educação digitais considerados inovadores e em curso afetam de facto a educação e, especificamente, os resultados escolares e a relação de estudantes com o saber." (p. 7) [4]. A atenção a estes aspetos é essencial para garantir que o tipo de competências que estão a ser desenvolvidas pelos alunos não se limitam ao domínio tecnológico, e que se investe no desenvolvimento de competências fundamentais, como o pensamento computacional, o pensamento crítico, a resolução de problemas, a criatividade, a cooperação, etc. [4].

Reconhece-se que a digitalização transformou o modo como se aprende e, em vários contextos, os alunos são já incentivados a usar, na sala de aula, dispositivos eletrónicos (p. ex. computadores, tablets, telemóveis) que lhes permitem aceder rapidamente a uma variedade de recursos digitais e a explorar a informação de novas formas [5].

Em particular, a aprendizagem baseada em jogos digitais é considerada uma via educativa importante para melhorar a educação nas salas de aula do futuro [6]. Vários estudos mostram que esta opção pode permitir diversificar o ensino, aumentar o interesse e a motivação dos alunos e proporcionar experiências de aprendizagem positivas e eficazes [6, 7, 8]. No entanto, a aprendizagem é uma questão complexa e a eficácia dos jogos neste processo não pode ser considerada inquestionável [6].

Os jogos podem ser muito atrativos, mas não contribuírem para os resultados de aprendizagem pretendidos, ou podem ter muito valor do ponto de vista educativo, mas serem incapazes de despertar o interesse dos alunos [9]. Não se trata, portanto, de simplesmente criar jogos divertidos para os alunos jogarem, mas sim de conceber atividades de aprendizagem que introduzem conceitos de forma progressiva e orientem os alunos para um objetivo final, garantindo equilíbrio entre a diversão e a aprendizagem [10].

A mecânica e a estética dos jogos despertam o interesse pela atividade de jogar [7] e, consequentemente, na motivação e atitude dos alunos para a aprendizagem [11]. A ideia de atingir um determinado objetivo e a possibilidade da existência de níveis e de atribuição de pontos proporciona aos alunos um ambiente competitivo, no sentido de os levar a querer ultrapassar os desafios, e a um sentimento de realização e satisfação [11].

Para além de os jogos educativos digitais proporcionarem o envolvimento afetivo (emoções e crenças), comportamental (grau de motivação) e cognitivo (o modo como os alunos pensam), quando usados no contexto de sala de aula permitem, também, desenvolver o envolvimento social dos alunos, através da sua interação com os colegas e o/a professor/a [12]. A investigação salienta, também, que a criação de oportunidades de interação entre o professor e o aluno num contexto de uso de jogos educativos produz efeitos ao nível do desenvolvimento das competências dos alunos [6].

Contudo, os jogos educativos digitais assumem, só por si, valor, que é justificado por argumentos associados à melhoria do desempenho matemático e ao envolvimento dos seus utilizadores na atividade matemática, no sentido de desenvolverem atitudes positivas em relação a esta área [13].

Na verdade, existe uma perceção negativa sobre esta disciplina por uma parte significativa de alunos, que se traduz numa ansiedade matemática, ou seja, num "sentimento de tensão, apreensão ou medo que interfere com o desempenho em matemática" (p. 181) [14]. O reconhecimento desta situação tem constituído um dos motivos para o desenvolvimento de jogos educativos focados na matemática, no sentido de promover o interesse por esta disciplina e proporcionar momentos de aprendizagem descontraídos e com prazer [15].

Vários estudos sobre o uso de jogos educativos digitais, intencionalmente concebidos para desenvolver competências matemáticas nos alunos, revelam que este tipo de recursos ajuda os alunos a melhorar o seu desempenho em matemática e as suas crenças de autoeficácia [16, 17, 18]. Atividades de jogo podem ser importantes quer no aprofundamento da compreensão dos conteúdos matemáticos, possibilitando aos alunos resolver problemas mais complexos e desenvolver o pensamento criativo e crítico [2], quer em situações de aplicação que lhes permitam, por exemplo, rever conteúdos já abordados [6].

III. METODOLOGIA

Considerando que um dos objetivos do projeto RED era conceber e produzir recursos educativos digitais interativos, foi seguida uma metodologia de investigação-ação, em que protótipos dos vários jogos, foram experimentados e validados por alunos e professores do 1.º ciclo do ensino básico.

A. O processo de construção dos jogos

Numa primeira fase, o desafio proposto à equipa era transformar em RED um conjunto de materiais didáticos, anteriormente elaborados em 'papel', para serem utilizados por professores do 1º ciclo do ensino básico na sua sala de aula. Os recursos em papel tinham sido construídos com uma determinada intencionalidade, tendo presente a ideia de aprendizagem da matemática com compreensão e procurando promover o desenvolvimento de capacidades matemáticas essenciais como, por exemplo, a resolução de problemas.

No processo de transformação dos referidos materiais didáticos em RED, a equipa de Matemática assumiu que estes recursos seriam elaborados numa ótica de jogo interativo para alunos do 1.º ciclo. Decidiu, também, manter quer a perspetiva sobre o ensino e aprendizagem da matemática, quer os conteúdos de aprendizagem que tinham estado subjacentes à construção dos materiais iniciais. Além disso, considerou que os jogos a produzir deveriam ter as seguintes características:

- favorecer o envolvimento das crianças, ou seja, serem interativos e suficientemente desafiadores, mas adequados às capacidades dos jogadores, isto é, os jogadores devem sentir-se competentes para jogar e superar os desafios do jogo;
- apresentar diferentes níveis de dificuldade, para permitirem a progressão das aprendizagens a um ritmo adequado;
- incentivar uma relação positiva com a Matemática, pois pretendia-se que as crianças gostassem de jogar, experienciando sentimentos de prazer e satisfação;
- possibilitar que as crianças sentissem que têm controlo sobre o jogo, dando-lhes uma sensação de independência, de domínio, de autonomia, de poder e de liberdade;
- permitir, desejavelmente, começar a jogar sem necessidade de grandes instruções.

O trabalho desenvolvido foi muito para além da adaptação de materiais já feitos, pois a construção de RED implicou novas lógicas e novas formas de olhar para os conteúdos matemáticos. Foram, subsequentemente, elaboradas propostas de guiões de dez jogos de matemática, enviadas à equipa do iNOVA Media Lab. Cada uma das propostas deu corpo a um jogo que foi sendo desenvolvido em colaboração com a equipa referida.

Ao longo do processo de construção foram concebidos 10 jogos, associados a tópicos essenciais de Matemática, sendo que cada um está associado a uma profissão. A Fig.1 apresenta a designação de cada jogo, associada a uma profissão, e a sua incidência no respetivo tópico matemático.

Designação	**Incidência no tópico matemático**
Jogo 1 – O Pescador	Cálculo mental
Jogo 2 – A Agricultora	Localizar números na reta
Jogo 3 – O Camionista	Organização de dados
Jogo 4 – O Alpinista	Adição e subtração
Jogo 5 – O Construtor	Multiplicação e divisão
Jogo 6 – O Arqueólogo	Classificação de figuras
Jogo 7 – A Arquiteta	Planificação de sólidos
Jogo 8 – A Condutora de Drone	Orientação espacial
Jogo 9 – A Merceeira	Medida
Jogo 10 – A Analista	Representações gráficas em Organização e Tratamento de Dados

Fig. 1. Designação dos jogos e tópicos matemáticos associados

Associados a cada um dos jogos foram ainda construídos guiões didáticos, disponíveis em https://redge.dge.mec.pt/site/node/6, que relacionam cada um dos jogos com os tópicos matemáticos envolvidos, sugerem modos de utilização didática de cada um dos RED em contexto de sala de aula e dão exemplos de itens de avaliação relacionados com esses tópicos matemáticos.

B. O processo de validação dos jogos

Com o objetivo de validar os jogos, tanto ao nível do *design* do foro tecnológico como ao nível da sua relevância para apoiar a aprendizagem da matemática, foi organizado um processo de pilotagem em duas fases que decorreu em dois agrupamentos de escolas, designados por Agrupamento A e Agrupamento B, situados na zona centro do país e que envolveu um total de 20 turmas (10 em cada uma das fases) do 1.º ciclo do ensino básico e as suas professoras titulares.

Como técnicas de recolha de dados durante o processo de pilotagem, recorreu-se à observação direta em contexto de sala de aula, a inquérito por questionário e a entrevistas, tanto a docentes como a alunos. Os alunos envolvidos, num total de 397, realizaram ainda um pré-teste e um pós-teste, antes e depois de terem contactado com os jogos.

A primeira fase de pilotagem envolveu os cinco primeiros jogos e decorreu entre fevereiro e maio de 2021. A segunda fase incidiu nos cinco últimos e realizou-se nos meses de fevereiro e março de 2022. Tendo em conta o contexto pandémico causado pela Covid-19, as sessões de trabalho com as professoras foram todas a distância, tendo tido uma duração de duas a três horas cada uma.

Em cada fase de pilotagem foram realizadas três reuniões com as professoras do 1.º ciclo envolvidas. Numa primeira reunião de trabalho foram apresentadas as opções didáticas em que assentou a construção dos jogos e o modo como foram operacionalizadas, bem como as opções metodológicas seguidas no processo de pilotagem. Depois de um espaço dedicado à exploração autónoma dos jogos, foram analisadas algumas das suas características e referida a estrutura dos guiões didáticos de apoio a cada jogo. Até à reunião seguinte cada professora analisou o jogo com que iria trabalhar com os seus alunos, bem como as respetivas indicações didáticas.

Numa segunda reunião de trabalho cada professora trabalhou com uma das investigadoras, selecionando as questões a incluir no pré-teste e no pós-teste e decidindo sobre o modo de recolher os resultados obtidos. Foram, também, agendadas entrevistas a alunos (3 por turma). Estes foram selecionados de acordo com dois critérios em simultâneo: (i) serem bons informantes e (ii) terem jogado pelo menos um dos jogos.

Durante a pilotagem as entrevistas aos alunos foram realizadas em dois momentos: logo após a realização do pré-teste (entrevistas iniciais, na primeira fase) e no final da exploração dos jogos (entrevistas finais). As entrevistas iniciais focaram-se no modo como cada aluno lidava com os ecrãs do jogo e avançava, respondendo às questões que surgiam. Em qualquer uma das fases de pilotagem, as entrevistas finais ocorreram depois da realização do pós-teste, tendo sido realizadas pelas investigadoras da equipa RED. No total foram realizadas 69 entrevistas a alunos.

Os itens incluídos no pré-teste e no pós-teste foram os mesmos, uma vez que, tendo em conta a idade dos alunos, a distância superior a um mês entre a sua aplicação, as condições em que esta aplicação decorreu e o tipo de itens considerados, não se considerou plausível que aqueles memorizassem as respostas corretas para cada item. Entre a realização do pré-teste e do pós-teste, os alunos tiveram oportunidade de explorar livremente o jogo em casa. Também foi solicitado às professoras que procurassem integrar a sua exploração nas aulas a distância ou presenciais.

Após a segunda reunião com as professoras do 1.º ciclo, as investigadoras observaram a exploração dos jogos pelas professoras e seus alunos em contexto de sala de aula. Foram envolvidos diferentes anos de escolaridade, de acordo com os tópicos matemáticos associados a cada um dos jogos. Após a exploração dos jogos, foram realizadas, pelas investigadoras, entrevistas a três alunos por turma, cujo objetivo era analisar o modo como exploravam autonomamente o jogo e perceber globalmente o interesse com que tinham acompanhado o trabalho em torno do jogo e a frequência com que o tinham jogado por sua própria iniciativa.

A terceira e última reunião de cada fase de pilotagem foi realizada, simultaneamente, com as professoras dos dois Agrupamentos e focou-se num balanço global do trabalho. Nesta reunião, cada participante relatou sucintamente a experiência associada à exploração dos jogos com os seus alunos, identificando potencialidades e limitações. Todas as reuniões foram gravadas e, posteriormente, analisados os dados recolhidos. Além disso, as professoras responderam a um questionário sobre os jogos e as suas potencialidades.

C. *Os jogos construídos*

Os jogos construídos são recursos disponíveis na internet (Fig. 2), com acesso livre e podem ser usados a partir de um computador, de um *tablet* ou de um telemóvel.

Fig. 2. Parte da Ilha Periscópio que dá acesso aos RED na área da Matemática, disponível em https://redge.dge.mec.pt/ilha/

Todos os jogos consistem na realização de um percurso em que são propostos desafios que o aluno deve superar (Fig. 3). A sua conceção enquanto ferramenta de aprendizagem integra os resultados da investigação realizada a nível internacional sobre cada um dos tópicos matemáticos em que incide.

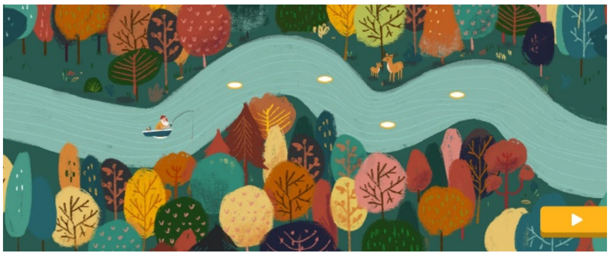


Fig. 3. Imagem que mostra o percurso a realizar no jogo 1 – O Pescador, a propósito de uma das operações aritméticas selecionadas

Deste modo, os desafios de cada jogo têm subjacente uma filosofia geral, concretizada para cada tópico, de progredir a partir do que cada um sabe para avançar no seu conhecimento associado aos conceitos matemáticos envolvidos.

Uma característica em que assentou toda a construção dos jogos é a interatividade, com *feedback* imediato, que integra sugestões para corrigir a resposta ou que a corrige. Todos os jogos se baseiam na constante interação entre o jogador e os desafios propostos nos jogos e a cada resposta ou seleção de imagem do aluno está associada um som que permite perceber a correção, ou não, da jogada realizada. O jogador, no caso de continuar a errar, perde vidas, mas tem sempre acesso à resposta correta e pode, em alguns casos, consultar exemplos que apoiam a autocorreção.

A pontuação obtida em cada jogo, associada ao número de vidas que se consegue preservar e ao tempo usado para jogar são importantes elementos que acentuam o caráter lúdico destes recursos. Também, a possibilidade de poder selecionar o nível de dificuldade favorece o interesse da criança em jogar, pois pode escolher livremente o percurso para o qual tem conhecimentos matemáticos suficientes ou em que se sente mais confiante. Embora o leque de opções seja mais limitado para as crianças no início da escolaridade (6/7 anos), também estas podem jogar várias das opções de muitos dos jogos propostos. Do mesmo modo, muitos dos jogos são adequados para a aprendizagem de alunos do 2.º ciclo (10/12 anos).

Globalmente, estes recursos oferecem desafios que cada um pode personalizar escolhendo o que mais se adequa aos seus conhecimentos. Cada um tem controlo sobre o jogo e pode viver uma experiência de aprendizagem independente e autónoma.

IV. O Uso dos Jogos e a Aprendizagem dos Alunos

Os dados relativos aos testes foram agrupados por item e cada item pode integrar mais do que uma pergunta. Os itens estão caracterizados nos guiões didáticos e cada um incide num dos aspetos matemáticos específicos e/ou grau de dificuldade em que incide cada jogo.

O conjunto de itens considerado para cada jogo vai de dois a seis, conforme as possíveis vertentes matemáticas que são focadas em cada um. Por isso, a análise dos resultados foi feita por item uma vez que é ele que caracteriza globalmente o conhecimento matemático revelado pelos alunos nos testes.

Nos casos em que o mesmo jogo foi realizado por alunos de anos de escolaridade diferentes, foram construídos testes distintos, de modo a atender à eventual diferença de conhecimentos. Apresentam-se, em seguida, as percentagens globais obtidas pelos alunos das turmas que exploraram cada um dos dez jogos, tanto no pré-teste como no pós-teste. Os dados relativos aos primeiros cinco jogos estão incluídos na tabela 1 e os dados sobre os outros cinco jogos encontram-se na tabela 2.

A análise da tabela 1 mostra que o jogo 2 foi explorado em duas turmas do 3.º ano e que o jogo 4 foi apenas experimentado numa turma, por questões de saúde de uma das professoras envolvidas na pilotagem. Globalmente, em todos estes cinco jogos, verificou-se um incremento na percentagem de alunos que melhoraram o seu desempenho, do pré-teste para o pós-teste, no que respeita aos aspetos avaliados.

Tabela 1. Percentagem de acerto dos alunos nos testes relativos aos jogos 1, 2, 3, 4 e 5

Ano	Percentagem de acerto por ano de escolaridade e por teste									
	Pré-teste					*Pós-teste*				
	J1	J2	J3	J4	J5	J1	J2	J3	J4	J5
1.º			82					87		
2.º	48					54				
3.º		84 77		89	81		87 91		91	86
4.º	59		74		56	83		95		67
Média	54	81	78	89	69	69	89	91	91	77

Uma análise global das percentagens de acerto nos pré-testes e nos pós-testes dos jogos 6, 7, 8, 9 e 10, revela que a percentagem de respostas certas no pós-teste aumenta sempre, tal como aconteceu nos jogos anteriores. Ainda assim, uma análise mais detalhada, por item, efetuada pela equipa de investigadoras, mostra que se registaram alguns decréscimos pontuais em alguns dos itens.

Tabela 2. Percentagem de acerto dos alunos nos testes relativos aos jogos 6, 7, 8, 9 e 10

Ano	Percentagem de acerto por ano de escolaridade e por teste									
	Pré-teste					*Pós-teste*				
	J6	J7	J8	J9	J10	J6	J7	J8	J9	J10
3.º	70	86	42	47	87	69	90	60	48	93
4.º	37	80	88	64	80	53	93	95	85	88

Ano	Percentagem de acerto por ano de escolaridade e por teste									
	Pré-teste					*Pós-teste*				
Média	54	83	65	56	84	61	92	78	67	91

A análise dos resultados obtidos tem necessariamente de ser contextualizada considerando três aspetos: (i) o contexto em que decorreram os testes; (ii) a integração da exploração dos jogos no trabalho letivo e (iii) as condições tecnológicas disponíveis.

Salienta-se que a exploração destes jogos enquanto recursos didáticos decorreu num contexto pandémico, marcado por fases de ensino a distância e por interrupções letivas inesperadas (quando algumas professoras contraíram Covid-19). Além disso, as professoras tiveram total liberdade para usar os jogos quando melhor entendessem e para adaptar as orientações didáticas disponibilizadas. Na prática, a maior parte delas não integrou, ou integrou durante pouco tempo, a exploração dos jogos na sua sala de aula, optando por incentivar o seu uso em casa. Esta tendência parece, também, estar relacionada com as condições tecnológicas disponíveis em cada escola e com o hábito de usar a tecnologia no ensino.

Ainda assim, os resultados obtidos revelam que a exploração dos jogos parece ter melhorado o desempenho dos alunos envolvidos no que respeita aos tópicos de ensino associados a cada um dos jogos.

V. A Perceção dos Alunos e das Professoras sobre os Jogos e as Suas Potencialidades

D. A perceção dos alunos sobre os jogos

Como foi anteriormente referido, na primeira fase de pilotagem foram realizadas entrevistas iniciais, que se focaram-se no modo como cada aluno lidava com os ecrãs do jogo e avançava, respondendo às questões que surgiam. Os dados recolhidos indicam que, de um modo geral, todos os alunos conseguiram identificar o foco de cada jogo, perceber como é que se avançava para jogar e como se obtinham pontos. Assim, cada um destes recursos está concebido de modo suficientemente intuitivo para permitir a sua exploração sem necessidade de qualquer apoio adicional. A vertente lúdica de cada jogo animou, particularmente, alguns alunos que mostraram um claro entusiasmo ao jogar.

Nas entrevistas finais, realizadas presencialmente, nas escolas, por elementos da equipa RED Matemática, alguns alunos sugeriram pequenas alterações relacionadas com o modo de perder/ganhar 'vidas', de tornar as situações para analisar menos repetitivas (jogo 9) ou sobre o número de tentativas permitidas. Apresentamos, em seguida, alguns excertos das entrevistas realizadas (a letra A é a inicial de aluno e a letra E a inicial de entrevistadora).

- A1: Outra coisa quando se faz um exercício ... só tens direito a duas vezes para fazer um exercício e depois passa a outro exercício se errares as duas. Mesmo que isso acontecesse devia dizer qual é que era a resposta do exercício. (4.º ano)
- E: O que sugeres para melhorar o jogo?

  A2: Haver mais vidas. (4.º ano)
- A3: Para complicar, se eu errava devia perder logo a vida. Pode ser uma sugestão de melhoria. Pode também haver mais países e cada vez que ganhamos pontos, o arqueólogo pode aparecer e pode dar uma vida se já a tivéssemos perdido. (3.º ano)
- Em todos os jogos, a apreciação global dos alunos foi muito positiva:
- A4: Acho que é divertido até para os adultos porque joguei com a minha mãe e ela também errou algumas coisas, mas aprendeu. (4.º ano)
- E: Então e imagina que hoje chegavas a casa e lhe dizias que estiveste a jogar. O que é que lhe dizias?
- A5: Que gostei muito do jogo, que tinha muitas perguntas, algumas mais difíceis que outras. Também concluí que no final do jogo as perguntas vão sendo mais difíceis. (3.º ano)

Unanimemente, associaram a experiência em torno dos jogos às palavras entusiasmo, alegria, aprender, fácil e diferente. Também se destaca a facilidade com que explicam o que deviam fazer para jogar e recordam os aspetos específicos de cada jogo:

- A6: Escolhe-se primeiro o volume, depois o nível de dificuldade e depois aparece uma espécie de imagem de mercearia … é como se uma merceeira fosse andando até às bolinhas amarelas. Depois carrega-se no Play e inicia-se a primeira etapa. Aparece os botões de um teclado, mas apenas com números. Uma tecla para apagar … e acho que tem outra que não me lembro. Depois tem a tecla do certo. Aparece uma imagem do outro lado e o objetivo é responder à pergunta medindo a medida dessa figura. (4.º ano)
- A7: Eu dizia que tinhas de escolher a casa ou o prédio e cada um tinha níveis. Ao clicar nos níveis tinhas perguntas sobre os sólidos. Para quem já deu essa matéria era fácil, mas para quem não deu era mais difícil. O jogo é muito divertido e apela à nossa imaginação porque temos de montar as pecinhas. (3.º ano)

E. A perceção das professoras sobre as potencialidades dos jogos

A análise das entrevistas e dos questionários evidencia que todas as professoras apreciaram muito positivamente as potencialidades do jogo que os seus alunos exploraram e reconheceram que pode ser feita facilmente uma articulação entre essa exploração e os conteúdos a lecionar. Por exemplo, uma das professoras de uma das turmas do 4.º ano de escolaridade refere que: "A partir do jogo há determinados pontos que podemos abordar, baseando-nos no jogo e tendo em conta as relações entre os números".

- Também salientaram, unanimemente, o interesse que cada jogo despertou nos alunos. Reconhecendo que esse interesse nem sempre foi igual para todos, destacam, ainda assim, a disponibilidade que muitos alunos manifestaram em explorar o jogo em casa ou nos momentos finais do dia de trabalho.
- Na primeira fase da pilotagem, em que havia turmas de 1.º e 2.º anos, cada professora referiu as partes de cada jogo que os seus alunos não podiam explorar por incidirem em conteúdos ainda não lecionados. No entanto, reconheceram que as opções iniciais dos jogos (relacionadas, por exemplo, com os universos numéricos), em articulação com a possibilidade de se optar por diferentes níveis de dificuldade, permitiram

sempre explorar pelo menos uma parte do jogo que não sentiram ser limitada.

- Na segunda fase da pilotagem, tal como se esperava, este aspeto não foi referido uma vez que ela envolveu, apenas, turmas de 3.º e 4.º anos. A apreciação da última parte do Jogo 8 foi considerada complicada e desinteressante para os alunos. Esta apreciação, coincidente com a da equipa da Matemática, permitiu que, já depois da pilotagem, fosse possível à equipa do iNOVA Media Lab introduzir uma alteração que, embora não correspondendo ao design inicial proposto pela equipa da Matemática, permite ultrapassar algumas das críticas identificadas.

VI. Considerações Finais

De um modo geral, podemos afirmar que os alunos exploraram os jogos sem necessidade de dispor de menus de ajuda adicionais aos já previstos. Além disso, os alunos entrevistados avaliam muito positivamente o jogo que usaram, identificando os aspetos matemáticos em que ele incide, o modo de jogar e a forma como é contabilizada a pontuação.

Embora na maior parte dos jogos a possibilidade de os explorar integralmente esteja dependente dos conhecimentos matemáticos dos alunos, os menus de opção permitem que todos os alunos possam explorar alguma parte destes recursos educativos. A maior parte dos alunos exploraram os jogos em casa ou na escola durante os intervalos ou no final do dia, o que, atendendo à tendência global de melhoria de resultados identificada nos pós-testes, sugere as potencialidades destes RED para apoiar a sua aprendizagem autónoma.

As potencialidades dos jogos são unanimemente reconhecidas pelas professoras participantes. Tanto na primeira fase de pilotagem como na segunda, a real integração dos jogos na planificação da professora foi reduzida por motivos de ordem diversa (constrangimentos causados pela pandemia, poucos recursos tecnológicos na escola, imposições da planificação prevista a nível geral). Ainda assim, estes resultados sugerem a importância de criar recursos adicionais para apoiar os professores a articular a exploração dos jogos com a planificação do seu ensino.

Agradecimentos

Esta investigação foi cofinanciada pelo POCH, o Portugal 2020 e o Fundo Social Europeu, através do Projeto Recursos Educativos Digitais (RED) (POCH-04-5267-FSE-000124) desenvolvido pela Direção Geral da Educação (DGE) em parceria com a Universidade Nova de Lisboa – iNOVA Media Lab, a Faculdade de Letras da Universidade de Lisboa, o Instituto Politécnico de Setúbal e a Universidade de Aveiro.

Referências

[1] OECD, "PISA 2022 Mathematics Framework," 2018. [Online]. Available: https://pisa2022-maths.oecd.org/pt/index.html

[2] M. I. Qureshi, N. Khan, D. Raza, A. Imran, and F. Ismail, "Digital Technologies in Education 4.0. Does it Enhance the Effectiveness of Learning? A Systematic Literature Review," International Journal of Interactive Mobile Technologies (iJIM), vol. 15, no. 4., 2021, pp. 13-43. [Online]. Available: https://doi.org/10.3991/ijim.v15i04.20291

[3] European Commission, "Digital Education Action Plan," European Commission, 2018. [Online]. Available: https://education.ec.europa.eu/focus-topics/digital-education/action-plan.

[4] J. C. Silva, J. Tribolet, L. Capucha, S. M. Silva and P. Veiga, "O Digital na Educação", 2022. [Online]. Available: https://www.cnedu.pt/content/edicoes/estudos_e_relatorios/O_Digital_na_Educacao_2022.docx.pdf

[5] A.A. Korostelev, I.M. Morozova, M.L. Gruzdeva, Z.V. Smirnova, O.I. Vaganova, A.V. Chanchina and S.M. Maltseva, "Modern information and communication technologies in the advanced education of children," International Journal of Innovative Technology and Exploring Engineering, vol. 8, no. 9, 2019, pp. 2376–2382.

[6] L. Bertram, "Digital Learning Games for Mathematics and Computer Science Education: The Need for Preregistered RCTs, Standardized Methodology, and Advanced Technology," Frontiers in Psychology, vol. 11, 2020. [Online]. Available: https://doi.org/10.3389/fpsyg.2020.02127

[7] S. Y. Cheung and K. Y. Ng, "Application of the Educational Game to Enhance Student Learning," Frontiers in Education, vol. 6, 2021. [Online]. Available: https://doi.org/10.3389/feduc.2021.623793

[8] M. Dabbous, A. Kawtharani, I. Fahs, Z. Hallal, D. Shouman, M. Akel, M. Rahal, and F. Sakr, "The Role of Game-Based Learning in Experiential Education: Tool Validation, Motivation Assessment, and Outcomes Evaluation among a Sample of Pharmacy Students," Education Sciences, vol. 12, no. 434, 2022, pp. 01-13. [Online]. Available: https://doi.org/10.3390/educsci12070434

[9] L. Pan, A. Tlili, J. Li, F. Jiang, G. Shi, H. Yu, and J. Yang, "How to Implement Game-Based Learning in a Smart Classroom? A Model Based on a Systematic Literature Review and Delphi Method," Frontiers in Psychology, vol. 12, 2021. [Online]. Available: https://doi.org/10.3389/fpsyg.2021.749837

[10] L. Sera and E. Wheeler, "Game on: The Gamification of the Pharmacy Classroom," Currents in Pharmacy Teaching and Learning, vol. 9, no. 1, 2017, pp. 155–159. [Online]. Available: https://doi.org/10.1016/j.cptl.2016.09.012

[11] W. D. Haddad and A. Draxler, Technologies for education: potentials, parameters, and prospects. USA: UNESCO and the Academy for Educational, 2002.

[12] N. M. Ismaizam, S. F. A, Rahman, S. N. S. M. Ahmad, N. I. I. M. Nazri, N. A. A. Idris, N. A. Ali, N. F. B. M. Rafi, S. N. A. Mohamad, A. A. A. Rahim, K. K. A. Rashid, and A. M. A. Aldaba, "An Integration of Game-based Learning in a Classroom: An Overview (2016 - 2021)," International Journal of Academic Research in Progressive Education and Development, vol. 11, no 1, 2022, pp.1207-1221. [Online]. Available: https://doi.org/10.3389/fpsyg.2021.749837

[13] A. Katmada, A. Mavridis, and T. Tsiatsos, "Implementing a Game for Supporting Learning in Mathematics," The Electronic Journal of e-Learning, vol. 12, no. 3, 2014, pp. 230-242. [Online]. Available: https://academic-publishing.org/index.php/ejel/article/view/1695

[14] M. H. Ashcraft, "Math Anxiety: Personal, Educational, and Cognitive Consequences," Current Directions in Psychological Science, vol. 11, no. 5, 2002, pp. 181-185. [Online]. Available: https://doi.org/10.1111/1467-8721.00196

[15] R. R. O. Galvão, D. J. Barbosa, and F. A. D. Faria, "Jogos Digitais Aplicados à Matemática no Ensino Fundamental: Uma Abordagem na Visão dos Alunos," Revistal Digital FAPAM, vol. 9, no. 1, 2019, pp. 1-9. [Online]. Available: https://periodicos.fapam.edu.br/index.php/synthesis/article/view/182/179

[16] L. Pareto, T. Arvemo, Y. Dahl, M. Haake, and A. Gulz, "A Teachable-Agent Arithmetic Game's Effects on Mathematics Understanding, Attitude and Self-Efficacy," In: Biswas, G., Bull, S., Kay, J., Mitrovic, A. (eds) Artificial Intelligence in Education. AIED 2011. Lecture Notes in Computer Science, 2011, pp. 247-255. [Online]. Available: https://doi.org/10.1007/978-3-642-21869-9_33

[17] W. F. B. W. Ahmad and N. H. B. A. Latih, "Development of a Mathematics Courseware: Fractions," Proceedings of the Fifteenth Asian Technology Conference in Mathematics, 2010, pp. 17-21. [Online]. Available: https://atcm.mathandtech.org/EP2010/regular/3052010_18223.pdf

[18] Y. L. Lee, "Enhancement of Fractions from Playing a Game. Crossing divides: MERGA 32," Proceedings of the 32nd Annual Conference of the Mathematics, vol. 1, 2009, pp. 323-330.

VIDEOJUEGO EDUCATIVO "SCRATCH ESTADÍSTICO" PARA LA ENSEÑANZA DE ESTADÍSTICA

De la Hoz Ruiz, Antonio

Departamento Ciencias de la Computación, Arquitectura de Computadores, Lenguajes y Sistemas Informáticos y Estadística e Investigación Operativa

Universidad Rey Juan Carlos
Madrid, España

a.delahoz.2021@alumnos.urjc.es

Hijón Neira, Raquel

Departamento Ciencias de la Computación, Arquitectura de Computadores, Lenguajes y Sistemas Informáticos y Estadística e Investigación Operativa

Universidad Rey Juan Carlos
Madrid, España

Raquel.hijón@urjc.es

***Resumen* - La enseñanza de la Estadística ha adquirido en los últimos años una creciente atención en todas las disciplinas**

académicas universitarias por lo que es, de especial importancia, adquirir una base sólida en las etapas de secundaria y

bachillerato.

Debido al cambio de paradigma con la inclusión de los recursos tecnológicos en las aulas, un gran reto al que se enfrenta la comunidad docente es producir un cambio en la percepción de los estudiantes hacia su capacidad de aprendizaje, ayudándoles a sintetizar y profundizar en la compresión de los contenidos mediante la aplicación de TICs.

Este artículo describe el diseño, desarrollo y evaluación de un videojuego educativo implementado con Scratch para la enseñanza de la Estadística en 1º Bachillerato, que permite crear nuevos contextos de aprendizaje a través de un recurso TIC.

La aplicación se llama "Influencer Estadístico" y consiste en un juego donde el objetivo es conquistar las redes sociales superando las actividades propuestas para cada bloque de estadística

Una vez se accede, solo se encuentra desbloqueado el Nivel 1, donde los alumnos van a poder reforzar la teoría y ponerla en práctica con las actividades propuestas. En el apartado práctico, van a recibir distintas puntuaciones en función de los intentos necesarios para elegir la opción correcta. Además, se activa un icono de ayuda cuando la respuesta es incorrecta.

Después de diseñar y desarrollar el videojuego, se ha evaluado y aplicado una prueba piloto en un aula para comprobar si su implementación favorece, no solamente el aprendizaje de los contenidos sino también la percepción y el atractivo de la Estadística a la hora de afrontarla. Se analiza un cuestionario de ejercicios de Estadística que tiene un diseño pre-test y post-test. La aplicación se encuentra almacenada en el siguiente enlace: https://scratch.mit.edu/projects/861471667/fullscreen/

Palabras Claves—videojuegos educativos, Scratch, Tecnología Información y Comunicación (TIC), Estadística, Innovación Educativa

***Abstract* - In recent years, teaching Statistics has been introduced in all university academic disciplines, so it is of special importance to acquire a solid foundation in secondary and high school stages.**

The inclusion of technological resources in the classroom has produced a paradigm shift, now the teaching community is facing a major challenge in terms of producing a change in the students' perception of their learning ability by helping them to synthesize and deepen the understanding of the contents through the application of ICTs.

This article describes the design, development and assessment of an educational video game implemented with Scratch in order to teach Statistics in A levels, which allows the students the creation of new learning contexts through an ICT resource.

The app is called " Influencer Estadístico" and it consists of a game where the main goal is to conquer the social networks by overcoming the activities proposed for each statistics section.

Once you access to the app, only Section 1 will be unlocked where the students will be able to reinforce the theory and put it into practice with all the proposed activities. In the practical section, they will receive different scores, depending on the number of attempts needed to choose the correct option. In addition, a help icon is activated when the answer is incorrect.

After designing and developing the videogame, a pilot test has been evaluated and applied in a classroom to confirm if its implementation benefits the students, not only learning the contents but also the perception and attractiveness of Statistics when facing it. Statistics Questionnaires, based on Pre-Test and Post-Test design, containing Statistics exercises will be analyzed. This app is stored in the following link: https://scratch.mit.edu/projects/861471667/fullscreen/

Keywords—educational videogames, Scratch, Information and Communications Technology (ICT), Statistic, Educational Innovaiton

I. INTRODUCCIÓN

El objetivo de esta investigación es diseñar y desarrollar un videojuego educativo basado en el lenguaje de programación Scratch para la enseñanza de la Estadística en 1º de Bachillerato.

En este juego, el estudiante tiene como principal meta conquistar las redes sociales superando las actividades propuestas para cada bloque de Estadística.

En cada bloque, el jugador puede reforzar la teoría y ponerla en práctica en las actividades propuestas donde deberá ir consiguiendo el mayor número de "followers" (puntuación) para hacerse con cada una de las redes sociales asignadas en cada sección.

El público objetivo se constituye de estudiantes que se encuentran en Bachillerato ya que el videojuego está creado con los contenidos de Estadística para el currículo de 1º de Bachillerato.

La enseñanza de la Estadística está presente en todas las ramas educativas por lo que es, de especial importancia, adquirir una base sólida en las etapas donde se empieza el proceso de aprendizaje (secundaria y Bachillerato).

Juntando los conocimientos informáticos de Raquel Hijón y los conocimientos estadísticos de Antonio de la Hoz, planteamos crear un videojuego educativo en el que se enseñará la Estadística de forma dinámica y atractiva.

II. Estado del Arte

Se analizan recursos relacionados con la aplicación de Scratch en la enseñanza y la integración de las tecnologías de la información y la comunicación en los procesos de aprendizaje para Estadística para conocer cuál es el estado de la cuestión.

A. Scratch

Debido al cambio de paradigma con la inclusión de los recursos tecnológicos en las aulas, un gran reto al que se enfrenta la comunidad docente es producir un cambio en la percepción de los estudiantes hacia su capacidad de aprendizaje, ayudándoles a sintetizar y profundizar la compresión de los contenidos mediante la aplicación de TICs.

A las nuevas generaciones se les atribuyen relaciones con la tecnología desde muy pronta edad y, en las metodologías de enseñanza se están incorporando con mayor frecuencia el uso de videojuegos educativos y otros recursos tecnológicos.

Algunas investigaciones realizadas en los últimos años confirman que enseñar informática es enseñar a los estudiantes a resolver problemas, diseñar soluciones y explotar su creatividad. Todo ello, aplicado desde la ciencia hasta las humanidades, donde se ven afectadas las matemáticas y la capacidad de pensamiento lógico. ([1]Chang C., Chang CK & Chin Yl, 2016).

En el mismo estudio, se afirma que Scratch 2.0 puede ayudar a los estudiantes a percibir las operaciones matemáticas y resolver los problemas matemáticos con una curva de aprendizaje más fluida mediante una interfaz de programación sencilla de usar.

El primer lenguaje de programación para procesos educativos en alumnos de primaria fue LOGO (Feurzeig, Papert, & Lawyer, 2011). El principal objetivo es utilizar los lenguajes de programación como soporte diseñado para ayudar a cambiar la forma de percibir las matemáticas. (Papert,1990).

Al igual que Logo, el lenguaje SET Interactivo se ha usado como método de aprendizaje en la asignatura de Matemáticas. Adicionalmente, de las muchas personas dispuestas a aprender Matemáticas, pocas de ellas conseguían tener éxito en el aprendizaje de las Matemáticas ([3]Dubinsky, 1995).

Por todo esto, se aplicó el poder del pensamiento computacional en la enseñanza de las Matemáticas, de modo que la instrucción que se usa en SET Interactivo surgió en base al aprendizaje matemático: la teoría APOS (Acción, Proceso, Objeto y Esquema).

Como consecuencia del aprendizaje con el lenguaje Logo, apareció el entorno de programación Scratch en el MIT (Resnick, 2012).

Scratch es un entorno de programación visual diseñado para presentar la programación a niños y adolescentes de una manera "más pensable, más significativa y social". (Liao SM, 2022)

Son varias las investigaciones realizadas en los últimos años que han propuesto el uso de la programación visual para introducir las operaciones matemáticas, y así, crear un entorno de aprendizaje integrando las matemáticas en la programación de Scratch (Grover, Pea, & Cooper, 2015; Han, Bae, & Park,2016).

B. Enseñanza de la Estadística

En la actualidad, enseñar Matemáticas y más en particular Estadística, no significa únicamente desarrollar ejercicios, hacer tareas y aprobar exámenes escribir, sino que va un paso más allá y debe integrar recursos digitales para comprender la abstracción de las operaciones matemáticas y los procesos de pensamiento lógico. (Chang C., Chang CK & Chin Yl, 2016).

En este mismo artículo, se integró un lenguaje de programación enfocado a la Estadística, como es Python, en otro lenguaje de programación basado en bloques diseñado para procesos educativos, como es Scratch. El objetivo era expandir la funcionalidad de Scratch y enfocarlo a un proceso de aprendizaje de Estadística favoreciendo el razonamiento estadístico a través de componentes básicos de Scratch y Python.

Basándonos en la literatura académica (Hickmott, Prieto-Rodríguez, & Holmes 2018), parece una realidad generalizada que existe una barrera en todos los ámbitos educativos para el aprendizaje de la Estadística.

En otro artículo, se comparó y analizó el impacto de la realidad aumentada en el desempeño de los alumnos, tanto a nivel de aprendizaje como de colaboración y compromiso en relación con el razonamiento estadístico. Los hallazgos del estudio sugirieron que la motivación en el aprendizaje y los logros de los estudiantes se vieron favorecidos con el uso de la realidad aumentada. ([2]Conley Q., Atkinson RK., Nelson BC., 2020)

Como tal, el uso de recursos relacionados con la Tecnología de la Información y la Comunicación ofrece una gran oportunidad para descubrir y ofrecer unas vías que faciliten que los estudiantes aprendan habilidades básicas de razonamiento estadístico de forma real y atractiva.

III. Objetivos

El objetivo principal de esta investigación ha sido diseñar, desarrollar y evaluar un videojuego educativo implementado con Scratch para la enseñanza de la Estadística en 1º Bachillerato, que permite crear nuevos contextos de aprendizaje a través de un recurso TIC.

Los bloques que se trabajan durante el videojuego son:

- Tablas de Contingencia
- Distribución Conjunta y Marginal
- Independencia y Dependencia de Variables
- Dependencia Lineal de las Variables
- Regresión Lineal

Por lo tanto, como objetivos específicos se encuentran:

OBJ-01: Diseñar y desarrollar un videojuego educativo para enseñar Estadística

OBJ-02: Validación de los instrumentos de recogida de datos.

OBJ-03: Análisis de las puntuaciones medias y su variabilidad en la muestra analizada.

OBJ-04: Eficacia del Programa: Analizar si existen diferencias significativas entre las puntuaciones del post-test y pre-test.

Preguntas de Investigación

PI1: ¿Puede un videojuego educativo mejorar de manera significativa la enseñanza de la Estadística?

PI2: ¿Existen diferencias significativas entre las puntuaciones de los alumnos antes de usar el videojuego y las puntuaciones de después?

Hipótesis de la Investigación

H1: La aplicación del videojuego basado en Scratch mejora el aprendizaje de Estadística.

H2: Es posible aprender Estadística en bachillerato con un videojuego diseñado en Scratch.

H3: No existen diferencias significativas entre las puntuaciones del post-test y pre-test.

H4: Las puntuaciones medias expresadas por los alumnos no son mayores en el post-test respecto al pre-test.

IV. Diseño

La propuesta llevada a cabo en el videojuego combina una serie de detalles que permiten cubrir los principales objetivos de la investigación. La aplicación tiene una estética basada en la relación existente de la estadística con las redes sociales. A continuación, se van detallando cada uno de estos detalles.

A. Menú de Bienvenida

Cuando el alumno accede al videojuego, ya percibe las dos ideas claras de la aplicación:

1. Objetivo de conquistar las redes sociales
2. Relación e importancia de la Estadística con las plataformas sociales.

En la parte superior aparece el título del juego; en la parte central, un texto donde se muestra y ejemplifica la presencia de la estadística en los contenidos de las redes sociales y, por último, en la parte inferior, se encuentra el botón para iniciar el juego.

En la pantalla siguiente, se selecciona el personaje con el que vamos a jugar y, para ello, se ofrecen distintos avatares.

Tras seleccionar nuestro “influencer”, se pasa a la interfaz que explica la información global del juego, instrucciones y metodología de puntuación.

B. Menú Principal o de Contenidos Estadísticos

La premisa fundamental del juego es cubrir todo el contenido que se aborda en el bloque de Estadística para 1º de Bachillerato. El planteamiento ha sido relacionar cada uno de los temas de Estadística con una red social distinta, quedando de la siguiente forma:

1. Twitter: Tablas de Contingencia
2. Facebook: Distribución Conjunta y Marginal
3. Instagram: Independencia y Dependencia de Variables
4. Tik Tok: Dependencia Lineal de las Variables
5. Twitch: Regresión Lineal

La interfaz que visualiza el jugador está compuesta por varios elementos:

- En la esquina superior izquierda se encuentra el título de la pantalla.
- En la parte superior derecha se encuentra un contador de puntos global.
- En el lateral izquierdo se encuentra una imagen de la red social correspondiente a cada contenido estadístico.

- En la parte central se muestra el tema de estadística asociado a cada bloque.
- En el lateral derecho se encuentra el contador de puntos específico por bloque.

C. Modelo de organización

En cada uno de los apartados del juego, se ha seguido el mismo patrón organizativo, que se basa en:

1- Apoyo y Enseñanza Teórica (Figura 1)
2- Ejercicios Prácticos

Figura 1: Pantalla de la Teoría

Al acceder a cada uno de los bloques, podemos reforzar la teoría o pasar directamente al apartado práctico. En la esquina inferior izquierda, tenemos dos botones con las letras *A y B* que nos posibilitan ir a la primera actividad o a la segunda. (Figura 2)

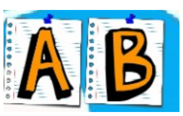


Figura 2: Botón de acceso a los ejercicios prácticos

El apartado práctico contiene dos tipos distintos de evaluación:

1. Multiple Choices: Opción Múltiple de respuesta única. (Figura 3)
2. Aplicación práctica y Realizar cálculos (Figura 4)

Figura 3: Pantalla de Actividad de Preguntas Múltiples (Actividad A)

Figura 4: Pantalla de la Actividad Práctica

En todas las actividades dónde hay que incluir o rellenar valores, se muestra un dibujo de un lápiz (Figura 5) dónde al hacer clic, nos permite introducir el valor.


Figura 5: Botón para incluir valores

Antes de cada ejercicio práctico, se presenta una interfaz explicativa que detalla en qué consiste la actividad a la que se accede.

Finalmente, una vez que se han completado todos los bloques, aparecerá la puntuación correspondiente a cada uno de ellos, así como la puntuación total del videojuego conocida como “Popularidad” en la esquina superior derecha.

V. Experimentación

A. Contexto

El I.E.S Sierra de las Villas se encuentra situado en un municipio de aproximadamente 11.000 habitantes. En el centro se imparten la Enseñanza Secundaria Obligatoria, Bachillerato, con dos modalidades: Humanidades y Ciencias Sociales y Ciencias. También se imparten Ciclos Formativos de Formación Profesional de Grado Medio y Gestión administrativa.

Concretamente, esta investigación se llevó a cabo en los alumnos de 1º Bachillerato de la modalidad de Ciencias.

B. Población y Muestra

A través de un muestreo aleatorio incidental (Mayorga & Ruiz, 2002) se seleccionaron 17 alumnos (n = 17) de primer curso de Bachillerato de Ciencias del I.E.S Sierra de las Villas.

C. Diseño y Variables

La metodología de esta investigación es experimental con un diseño pre-post de medidas repetidas, uno antes de probar el juego (Pre-Test[1]) y otro después de implementar el juego (Post-Test[2]).

Se realiza mediante esta vía para determinar como el juego mejora el proceso de aprendizaje.

Además, se realiza un juicio de expertos por parte del profesor para poder reportar bugs y proponer mejoras.

En esta investigación se tuvieron en cuenta las siguientes variables:

- Variables dependientes: puntuaciones directas en los Cuestionarios.

- Variables independientes: edad, tiempo (Pre-test y Post-test) y género (hombre y mujer).

- Variables intervinientes o controladas: nivel previo de estudios, dominio de la competencia informática, origen cultura y ausencia de necesidades educativas especiales.

D. Instrumentos de Recogida de Datos

Para medir los estándares de aprendizaje evaluables en el bloque de Estadística, se diseñó e implementó un cuestionario que consta de 28 ítems o preguntas.

Concretamente, la distribución de las preguntas se organiza en secciones quedando de la siguiente forma: a) Tablas de Contingencia (ítems 1 al 11), b) Distribuciones Conjuntas y Distribuciones Marginales (ítems 12 al 14), c) Independencia y Dependencia de Variables (ítems 15 a 17), d) Dependencia Lineal de las Variables (ítems 18 a 24) y e) Regresión Lineal (ítems 25 a 28)

E. Procedimientos

La aplicación del programa se distribuyó en tres fases:

Fase 1 (Pre-test). Presentación de los objetivos del experimento y Evaluación Inicial.

- Explicación
- Cuestionario de conocimientos estadísticos

Fase 2. Aplicación del videojuego y seguimiento

- Scratch Estadístico

Fase 3 (Post-test). Evaluación Final

- Cuestionario de conocimientos estadísticos
- Cuestionario de Opinión sobre el videojuego

VI. Resultados

Objetivo Específico: Fiabilidad de los Instrumentos de recogida de datos

El propósito es medir la fiabilidad de la escala de medida que hemos utilizado, para ello calculamos el Alfa de Cronbach que es el coeficiente que indica dicha fiabilidad.

La validez de un instrumento se refiere al grado en el que el instrumento mide aquello que se pretende medir.

TABLE I. Fialibilidad pre-test

Estadística de Fiabilidad	
Alfa de Cronbach	*N de elementos*
,714	33

Podemos observar que existe una buena confiabilidad ya que el valor de Alfa de Cronbach está por encima de 0.7 y por lo tanto, se considera Aceptable.

Objetivo Específico: Eficacia del Programa

Para la comparación de muestras relacionadas queremos estudiar si hay diferencias entre ambas y si estas diferencias hacen referencia a un incremento una disminución en las puntuaciones de Pre y Post.

Para obtener una primera percepción de las diferencias, en la siguiente tabla se muestra los valores de los principales estadísticos descriptivos para Pre Test y Post Test.

TABLE II. Estadísticos descriptivos

	Estadística Descriptiva			
	Media	*Mínimo*	*Máximo*	*Desv. Estándar*
Pre	23,06	13	30	4,465
Post	27,24	24	30	1,855

En el diagrama de Caja y Bigotes (Figura 6) se muestra a simple vista la media, mediana y los cuartiles para ambas puntuaciones y permiten de forma visual comparar distribuciones.

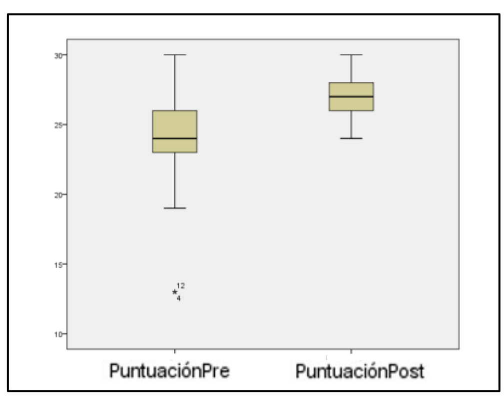


Figura 6: Boxplot

Para la comparación de muestras relacionadas se quiere estudiar si hay diferencias entre ambas muestras y si esas diferencias hacen referencia a un incremento o una disminución en las puntuaciones de Pre y Post; para ello aplicamos la prueba T de Student para muestras relacionadas donde la Hipótesis Alternativa significa que hay diferencias entre los distintos grupos.

TABLE III. MUESTRAS EMPAREJADAS PRE-TEST & POST-TEST

	Estadística de Muestras Emparejadas			
	Media	*N*	*Desv. Estándar*	*Error Estándar*
Pre	23,06	17	4,465	1,083
Post	27,24	17	1,855	0,450

En la tabla IV tenemos el Estadístico T, los grados de libertad (número de evaluaciones menos uno) y el p-valor (es el que más nos interesa). El p-valor tiene una cifra por debajo del nivel de significancia (0.05) por lo que rechazamos la Hipótesis Nula de H3 y nos quedamos con la Hipótesis del Investigador: Existen diferencias significativas entre las puntuaciones de Post-Test respecto a las de Pre-test.

TABLE IV. T DE STUDENT

	Pruebas de Muestras Emparejadas				
	Media	*Desv. Estándar*	*t*	*gl*	*Sig. (bilateral)*
Par1 Pre-Post	23,06	4,915	-3,504	16	0,003

VII. CONCLUSIONES

El objetivo de la investigación ha sido diseñar y desarrollar un videojuego de apoyo para la enseñanza de Estadística en 1º de Bachillerato. En “Scratch Estadístico” se integra el mundo de la Estadística en las redes sociales, ayudando y motivando al alumno en su proceso de aprendizaje.

Lo más relevante desde el punto de vista técnico es haber desarrollado el videojuego desde cero con un lenguaje de programación basado en bloques y poder implementarlo para conseguir un proceso de aprendizaje guiado, tanto por explicaciones textuales como por audios. Con esta consecución, se confirma que es posible aprender Estadística en Bachillerato con un videojuego diseñado en Scratch . Otro aspecto fundamental ha sido la generación de distintos bloques, cubriendo cada uno de los contenidos de Estadística, con una misma metodología: teoría, ejercicio práctico de respuestas única y una actividad de cálculos.

Para la H1, los resultados confirman la Hipótesis del investigador ya que, gracias a los procesos de diseño, aplicación y análisis, la aplicación del juego de Scratch mejora las puntuaciones de los alumnos para el aprendizaje de Estadística.

Con esta afirmación damos respuesta a la PI1 con la certeza de que un videojuego educativo puede mejorar la enseñanza de la Estadística.

Una de las principales innovaciones teóricas y metodológicas de esta investigación ha sido el diseño y validación del Cuestionario de Estadística.

Por último, para la H3 y la H4, los resultados presentan que, a través de la media, existen diferencias entre las puntuaciones totales de Pre y Post y que las puntuaciones medias son mayores en el post-test respecto al pre-test. Adicionalmente, una de las preguntas de investigación cuestiona si esas diferencias son significativas y con los resultados obtenidos, se observa que existen diferencias significativas entre las puntuaciones de Pre- Test y Post Test.

REFERENCES

[1] Chang C., Chang CK. And Chin YL, Experimental Functionality Development for Scratch Mathematical and Statistics Extensions,
International Computer Symposium (ICS), 2016, pp.640-644

[2] Conley Q., Atkinson RK., Nelson BC., ,MantarayAR: Leveraging augmented reality to teach probability and sampling, Computer & Education 153, August 2020

[3] Dubinsky, E., ISETL: A programming language for learning mathematics. *Communications on Pure and Applied Mathematics, 48*(9), 1027–1051, (Ed.). (1995).

[4] Feurzeig,W., Papert,S.A.,*Programming-languages as a conceptual framework for teaching mathematics.* Interactive Learning Environments 19(5): 487–501. (2011)

[5] Han, B., Bae, Y., & Park, J. (2016). The effect of mathematics achievement variables on Scratch programming activities of elementary school students. *International Journal of Software Engineering and Its Applications*, 10(12), 21–30.

[6] Hickmott, D., Prieto-Rodriguez, E., & Holmes, K. (2018). A scoping review of studies on computational thinking in K–12 mathematics classrooms. Digital Experiences in Mathematics Education, 4(1), 48– 69.doi:10.1007/s40751-017-0038-8

[7] Grover, S., Pea, R., & Cooper, S., Designing for deeper learning in a blended computer science course for middle school students. *Computer Science Education*, 25(2), 199–237, 2015.

[8] Liao, SM. Journal of Statistics and Data Science Education 31 (1),
January 2023, pp.45-56

[9] Papert, S.A. (1990). A critique of technocentrism in thinking about the school of the future. Cambridge, MA: Epistemology and Learning Group, MIT Media Laboratory.

[10] Resnick, M., Reviving Papert's dream. Educational Technology 52(4): 42–46, 2012.

SCAFFOLDING FOR VISUAL PROGRAMMING: DESIGN AND EVALUATION OF A MODEL-DRIVEN ENGINEERING APPROACH

Darwin Alulema
Universidad Rey Juan Carlos
Universidad de las Fuerzas Armadas ESPE
Sangolquí, Ecuador
doalulema@espe.edu.ec

Maximiliano Paredes-Velasco
Departamento de Informática y Estadística
Universidad Rey Juan Carlos,
Móstoles, Madrid, Spain

Abstract**—**The learning of programming is increasingly gaining importance; however, it is a task that many students consider difficult, as it involves understanding theoretical concepts, knowledge of syntax and semantics of a programming language, syntactic coding, and programming logic for constructing a solution to a problem. In this regard, this work presents the current state of a tool based on Model-Driven Engineering and Model-to-Text Transformations to facilitate the teaching of programming through scaffolding techniques. Eclipse Modeling Framework (EMF), Sirius, and Acceleo tools are employed for building this tool. To validate the tool, a comparative study is conducted between an experimental group that uses the designed tool and a control group that uses Eclipse IDE. Data is collected through questionnaires at the beginning and end of the experience, evaluating aspects such as emotions, acquired knowledge, and tool usability. The effectiveness of the tool and its impact on students' positive emotions, as well as knowledge enhancement, could be determined.

Keywords— Scaffolding, Ingeniería de Modelos, Enseñanza de la programación, Emociones, Usabilidad

I. INTRODUCCIÓN

La enseñanza de la programación es un tema de gran importancia en la actualidad, debido a la omnipresencia de la tecnología en todas las esferas de la actividad humana [1]. El Scaffolding, o andamiaje, se refiere al soporte temporal y estructurado que se proporciona a los estudiantes mientras adquieren nuevas habilidades y conocimientos [6]. En el contexto de la enseñanza de la programación, el Scaffolding se puede utilizar para guiar a los estudiantes a través de problemas y desafíos de programación, brindándoles estructuras y herramientas que los ayuden a comprender los conceptos fundamentales y a desarrollar soluciones efectivas [7]. Una de las metodologías que puede ser utiliza para el desarrollo de aplicaciones con técnicas educativos de Scaffolding es la ingeniería dirigida por modelos (MDE). Esto es debido a que MDE [2] permite la creación de modelos por parte de expertos en el dominio, lo que facilita la generación de lenguajes específicos del dominio y la automatización de procesos de gestión de proyectos [3]. Al emplear la ingeniería de modelos para desarrollar aplicaciones de Scaffolding, los especificadores pueden crear un entorno interactivo y accesible para explorar y practicar la programación. Estas aplicaciones pueden incluir características como editores de código, ejemplos de código predefinidos, documentación contextual y retroalimentación automatizada [4]. Una de las ventajas clave de utilizaraplicaciones de Scaffolding basadas en ingeniería de modelos essu capacidad para adaptarse a las necesidades individuales de losestudiantes [5]. Los modelos de especificación permiten la personalización de la experiencia de aprendizaje, brindando diferentes niveles de apoyo y desafío según las habilidades y el progreso de cada estudiante. Esto la hace una alternativa interesante para la construcción de herramientas para laenseñanza.

Este trabajo se pretende crear una herramienta, a la cual se la he denominado VILEP, para la enseñanza de la programación que incorpora Scaffolding. Para comprobar la validez de la herramienta se ha comparado el aprendizaje y las emociones de usar nuestra herramienta con un IDE estándar como Eclipse.

El artículo está estructurado de la siguiente manera: en la sección II se mencionan algunos de los trabajos que tratan sobre el uso de herramientas especializadas en Scaffolding para la enseñanza de la programación. La Sección III describe cómo se diseñó e implementó VILEP empleando ingeniería dirigida por modelos. En la sección IV describe la metodología seguida para la ejecución de la experiencia realizada para la validación de VILEP durante el proceso de aprendizaje en el aula, la sección V muestra el análisis de lis los resultados del uso de VILEP y la sección VI muestra las conclusiones y los trabajos futuros.

II. TRABAJOS RELACIONADOS

Al analizar los trabajos relacionados se identifican varios aspectos comunes y diferenciadores. Estos trabajos tienen en común el objetivo de abordar los desafíos del aprendizaje de la programación y mejorar la motivación de los estudiantes en este campo [8]. Se destaca la importancia del Scaffolding, que proporciona apoyo estructurado a los estudiantes, y se reconoce la necesidad de personalizar el aprendizaje para adaptarse a las necesidades individuales [9], [10]. En ese sentido se señala que el Scaffolding es una técnica que se utiliza para apoyar a los estudiantes en su proceso de aprendizaje, proporcionándoles el soporte necesario para que puedan avanzar en su aprendizaje de manera autónoma [11]. Además, el Scaffolding brinda apoyo estructurado y temporal a los estudiantes durante el proceso de aprendizaje. Esto se logra mediante la utilización de estrategias como proporcionar ejemplos, ofrecer ejercicios prácticos, dar retroalimentación efectiva y guiar paso a paso a los estudiantes [12].

Algunos trabajos se centran en enfoques pedagógicos específicos, como el aprendizaje basado en proyectos o el aprendizaje colaborativo, lo que puede influir en la implementación del Scaffolding y el uso de la ingeniería de modelos [13]. También se encuentran diferencias en los contextos de enseñanza, ya sea a nivel universitario, secundario o de formación profesional [14]. Además, se emplean diferentes tecnologías y herramientas, desde entornos virtuales de programación hasta plataformas en línea o aplicaciones móviles [9], [10], [15]–[17].

En cuanto al estado emocional y motivación de los estudiantes, se destaca su importancia en el rendimiento académico de los estudiantes de ingeniería [18]. Estos aspectos son un factor clave para el éxito en el aprendizaje de la programación, ya que los estudiantes necesitan estar motivados para aprender y practicar las habilidades necesarias para programar [19]. Asimismo, se aborda la mejora de la motivación a través de técnicas de gamificación [4]. Esto implica el uso de estrategias para proporcionar retroalimentación positiva, fomentar la autonomía de los estudiantes y crear un sentido de relevancia y propósito en las actividades de programación [20]. Además, en términos de la enseñanza de la programación, es importante fomentar la participación de los estudiantes y promover su autonomía en la resolución de problemas. Esto se logra a través de enfoques como la gamificación, la personalización del aprendizaje y la relevancia de los proyectos de programación [21].

III. DISEÑO

En esta sección se describen brevemente los detalles dediseño e implementación de VILEP, para lo cual se ha empleado ingeniería dirigida por modelos y transformaciones de modelo a texto que permiten construir una plataforma visual que incorpora Scaffolding. El diseño de VILEP requirió el empleo de tres componentes principales: a) un metamodelo creado con Eclipse Modeling Framework (EMF), en el cual se modeló los casos y relaciones, que se presentan en el paradigma de programación orientado a objetos; b) una interfaz gráfica de usuario diseñada en Sirius, en la cual se provee al estudiante unaforma visual, de diseñar los algoritmos sin entrar en los detallesespecíficos de la sintaxis del lenguaje de programación ; y c) unatransformación modelo a texto (M2T), especificada en Acceleo,que de acuerdo a un conjunto de reglas del modelo genera código Java. A continuación, se describen los pasos seguidos para diseñar VILEP:

1. Definir los requisitos de la aplicación: Antes de comenzar a diseñar VILEP, fue necesario definir las características del lenguaje Java que se incorporan en VILEP. Las funcionalidades que se desean implementar son: operadores aritméticos, condicionales y bucles.

2. Definir el modelo de VILEP: Una vez definidos los requisitos, se debe crear el modelo de la aplicación utilizando Eclipse Modeling Framework. Este modelo debe incluir todas las entidades y relaciones que se van a utilizar en la aplicación.

3. Diseñar la interfaz gráfica: A continuación, se debe diseñar la interfaz gráfica de la aplicación utilizando Sirius. Para lo cual se deben asociar componentes visuales a cada clase del metamodelo y especificar las relaciones y restricciones en cada clase.

4. Generar el código: Una vez diseñada la interfaz gráfica, se debe especificar la transformación M2T (Model-to-Text) que, a partir de una instancia específica del modelo, construya el artefacto de software. Esta transformación debe implementar las reglas de transformación escritas en Acceleo.

A. Definición del metamodelo

La figura 1 muestra el metomodelo definido por las metaclases y sus relaciones. Las meta clases más importantes de un programa orientado a objetos son:

- *Explanation:* representa el concepto de comentar un código fuente y permite al estudiante mostrar u ocultar una breve descripción del código que está creando a partir de su diseño.
- *Project:* representa el concepto de un proyecto creado por el estudiante.
- *Class:* representa las clases que el estudiante implementará en su proyecto.
- *Méthod:* representa los métodos o funciones de una clase.
- *Object:* agrupa las clases hijas Operator, Variable and Message, que representan respectivamente las operaciones matemáticas (suma, resta, multiplicación, división y resto); las declaraciones de las variables y los tipos de datos; y la lectura y salida de información por consola.
- *Argument:* modela los argumentos de entrada o salida de los métodos.

Estos componentes están relacionados entre sí: “Project” contiene “Class” y esta a su vez contiene “Méthod”. Los métodos están relacionados con otros métodos y pueden contener varios "Object" que representan operaciones matemáticas, lectura y escritura por teclado. Además, “Method” puede tener “Argument”, cuyas referencias permiten que los métodos tengan variables locales para sus operaciones.

B. Generación de código

La generación del código fuente es producto de una transformación del modelo a texto. Para lo cual se implementó en Acceleo las reglas de transformación de la lógica del programa a código Java:

- Creación de los archivos del programa.
- Declaración las bibliotecas requeridas para los métodos.
- Declaración de las clases.

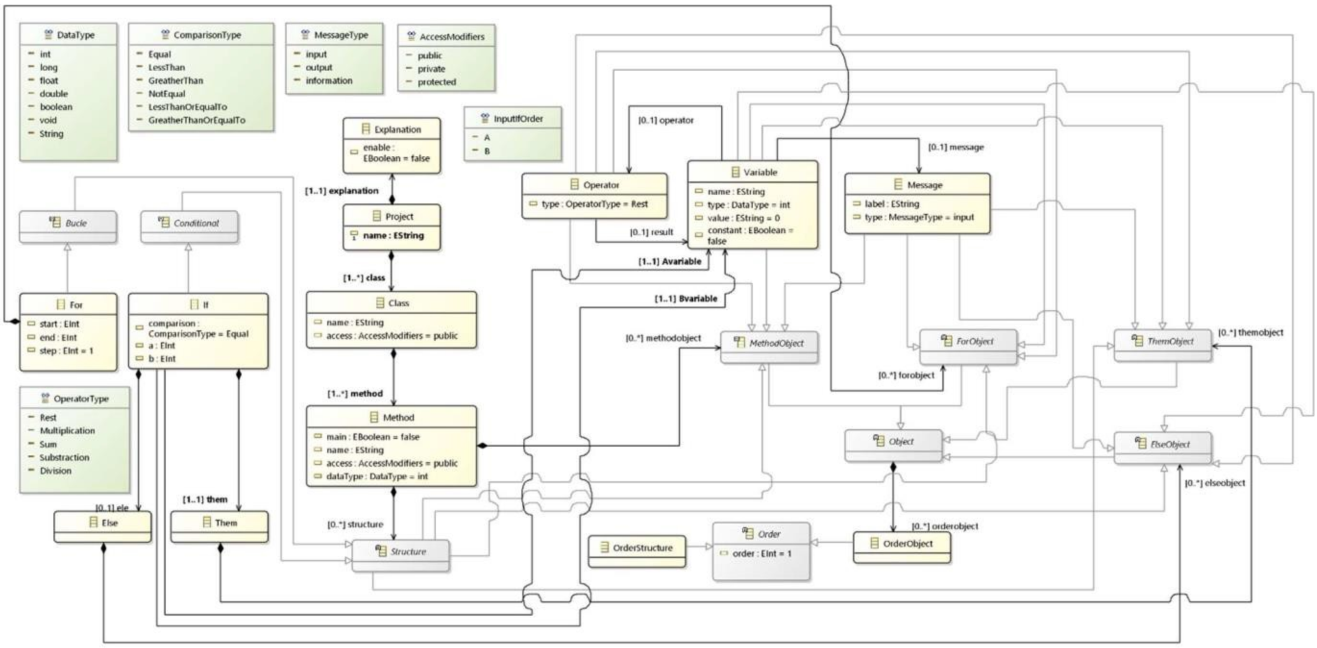


Figura 1. Metamodelo de VILEP

- Declaración de los métodos.
- Declaración de las variables utilizadas.
- Inicialización de variables.
- Realización de operaciones matemáticas.
- Visualización de valores.

Las reglas de transformación definidas, que transforman las expresiones gráficas del programa diseñado por el estudiante, generan código Java que contiene: a) Llamada a la Clase Scanner del paquete java.util para ingreso de datos por consola, b) Declaración de una instancia de Scanner para almacenar la información ingresada por consola, c) Declaración de variables, d) Escritura de mensajes en pantalla con el método println(), e) Ingreso de valores con el método nextLine() de la clase Scanner y escritura en mensajes en pantalla y almacenamiento en una variable, f) Declaración de operaciones, y g) Escribir en pantalla los resultados de operaciones con el método println().

IV. Interfaz gráfica de VILEP

La interfaz de usuario de VILEP permite al estudiante trabajar con conceptos básicos de programación orientada a objetos, como clases, métodos, argumentos, condicionales, bucles y también con otros conceptos de programación en general, como expresiones aritméticas, asignaciones, operaciones de entrada y salida. Estos conceptos están representados por componentes visuales disponibles (Figura 2) en una paleta de control, donde el estudiante puede seleccionar y arrastrar sobre el editor (llamado Canvas) y realizar el diseño de un programa. El editor visualiza la composición del programa en cada momento mostrando algunas partes de la sintaxis de Java y ocultando otras (las más complejas) mediante iconos visuales. Los diseños gráficos generados por el estudiante son interpretados con un flujo de lectura de arriba hacia abajo y de izquierda a derecha, que es traducido por VILEP generando un fichero ".java" con la sintaxis Java de el programa creado por el estudiante. Sin embargo, no se han considerado algunos conceptos como la declaración de objetos o la herencia por simplificar VILEP y ser conceptos que se pueden trabajar de forma paralela con otros recursos docentes.

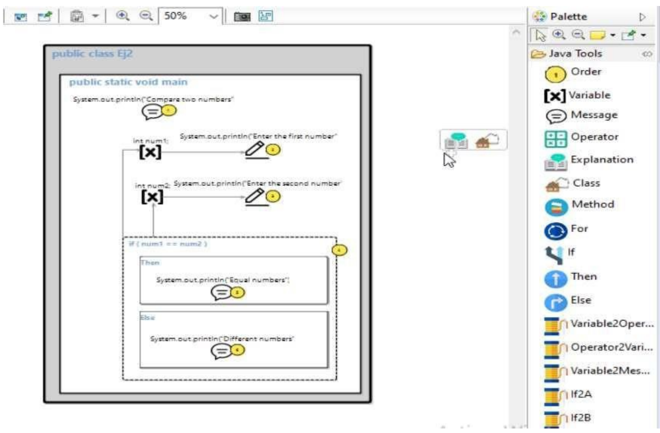


Figura 2. Interfaz de usuario de VILEP

Como la actividad del estudiante no se centra en la sintaxis del lenguaje, presenta una menor carga cognitiva, por lo que el estudiante puede centrarse más en los conceptos deprogramación durante la creación de programas. VILEP ofrece cuatro funcionalidades principales:

- Agregar declaraciones de clases, métodos y variables al programa. Estos componentes están en la paleta y el estudiante los arrastra para componer el programa.

- Realice la lectura y escritura de la consola (operaciones estándar de entrada y salida).
- Realizar operaciones matemáticas básicas (suma, resta, multiplicación, división y resto). Es posible asociar las variables con los valores a operar y la variable a la que se le asigna el resultado de la operación.
- Describir las invocaciones de métodos y estructuras de control selectivo e iterativo.

V. Metodología del estudio

Para aplicar VILEP diseñada se ha considerado un grupo de control y uno experimental, a los cuales se aplicaron dos tratamientos diferentes y se midieron varios aspectos. Se detalla a continuación estas cuestiones. Para la realización del estudiose siguieron los siguientes pasos:

1. Selección los grupos: Par el estudio se trabajó con estudiantes de segundo nivel de la carrera de Electrónica de la Universidad de las Fuerzas Armadas, en Ecuador. El grupo de control (GC) utilizó Eclipse IDE durante el proceso de aprendizaje de la programación, mientras que el grupo experimental (GE) utilizó VILEP diseñada.

2. Definir los cuestionarios: Se diseñó los cuestionarios para determinar el nivel de aprendizaje que se aplicará al inicio y al final de la experiencia. Además de seleccionó el test PANAS (Positive Affect and Negative Affect Scale) para medir las emociones experimentadas por los estudiantes durante la experiencia. Por último, se decidió utilizar el test de SUS (System Usability Scale) para medir la usabilidad de VILEP porparte de los estudiantes.

3. Preparación y orientación: Ambos grupos recibieron una orientación inicial sobre los objetivos y el formato del estudio. Se les explicó cómo se llevaría a cabo la experiencia, incluyendoel uso de VILEP diseñada por el grupo experimental y el uso del Eclipse IDE por parte del grupo de control.

3. Creación de los formularios: Se crearon por Google Forms los cuestionarios para medir las emociones, conocimientos de programación y usabilidad.

4. Realización de las tareas de aprendizaje Esta etapa de la investigación se realizó la intervención el aula con los estudiantes.

5. Seguimiento y recopilación de datos: Durante la experiencia, se realizaría un seguimiento de los avances y el progreso de los dos grupos. Esto podría incluir observaciones en el aula, registros de interacciones y posibles dificultades encontradas por los estudiantes.

6. Evaluación y comparación de resultados: Al final de la experiencia, se analizaron los datos recopilados de los cuestionarios administrados al inicio y al final. Se compararon los resultados entre el grupo experimental y el grupo de control para identificar posibles diferencias en las emociones y motivación, los conocimientos adquiridos y la usabilidad de la aplicación o del Eclipse IDE.

VI. Intervención en el aula

A. Objetivo

La experiencia con los estudiantes tuvo como objetivo validar si el uso de VILEP en un curso de introducción a la programación mejora los resultados de aprendizaje y el estado emocional del estudiante durante el proceso de aprendizaje.

B. Instrumentos y variables

Para la evaluación de la experiencia se consideró como variable independiente VILEP didáctica aplicada: en el GC la herramienta Eclipse, mientras que en el GE se utilizó VILEP. Las variables dependientes medidas fueron el nivel de conocimiento adquirido y las emociones positivas y negativas experimentadas. En ambos grupos se realizó un pre-test de estasvariables al inicio de la experiencia, y un post-test al final. Los instrumentos para medir estas variables fueron dos escalas. En primer lugar, una escala de conocimientos con 6 ítems multiopción diseñada específicamente para la experiencia. Esta escala planteó preguntas sobre conceptos básicos de programación orientada a objetos en los que el estudiante debía interpretar el código fuente en Java. En segundo lugar, se utilizóuna escala validada para medir emociones: PANAS de Watson. La escala está compuesta por 20 términos que describen emociones de carácter positivo o negativo (10 de ellos positivos y 10 negativos). Los estudiantes deben evaluar cómo se sienten ante cada uno de estos términos emocionales mediante una escala de Likert con 5 opciones de respuesta (nada, muy poco, algo, bastante y mucho). Además, se ha empleado el test de SUSen el grupo GE y no en el GC, debido a que el objetivo es evaluarla usabilidad de VILEP y no la de Eclipse, que es una herramienta estándar y conocida. El test de SUS consta de 10 preguntas definidas:

- P1. Creo que me gustaría utilizar este sistema con frecuencia
- P2. Encontré el sistema innecesariamente complejo
- P3. Pensé que el sistema era fácil de usar
- P4. Creo que necesitaría el apoyo de un técnico para poder utilizar este sistema
- P5. Encontré que las diversas funciones de este sistema estaban bien integradas
- P6. Pensé que había demasiada inconsistencia en este sistema
- P7. Me imagino que la mayoría de la gente aprendería a utilizar este sistema muy rápidamente
- P8. Encontré el sistema muy complicado de usar
- P9. Me sentí muy seguro usando el sistema
- P10. Necesitaba aprender muchas cosas antes de empezar con este sistema

Como ya se ha indicado, para llevar a cabo el estudio se ha evaluado la usabilidad, conocimiento y las emociones experimentadas, para lo cual se definieron las siguientes variables:

- CONOCIMIENTO_PRE: Son los resultados del nivel de conocimientos al inicio de la experiencia.
- CONOCIMIENTO_POS: Este es el conocimiento de los estudiantes después de la experiencia.
- EMOCIONES_POSITIVAS_PRE: Son las emociones positivas de los estudiantes al inicio de la experiencia.
- POSITIVE_EMOTIONS_POS: Muestra las emociones positivas de los estudiantes después de la experiencia.
- NEGATIVE_EMOTIONS_PRE: Mide las emociones negativas de los estudiantes al inicio de la experiencia.
- EMOCIONES_NEGATIVAS_POS: Son las emociones negativas de los estudiantes al final de la experiencia.

C. *Proceso*

La experiencia se llevó a cabo con los estudiantes del curso de Programación. La experiencia comenzó explicando a los estudiantes los objetivos de la actividad. Luego, los participantes fueron organizados aleatoriamente en dos grupos: a) GE, grupo conformado por 21 participantes que utilizaron VILEP, y b) GC, grupo conformado por 17 participantes que el método de enseñanza habitual utilizando el entorno Eclipse. Estos dos grupos, aunque en la planificación original fueron de el mismo tamaño al momento de la ejecución de la experiencia no asistieron 4 personas del grupo de control,

Una vez constituidos los grupos, se inició la intervención con una primera valoración de los conocimientos y estado emocional de los estudiantes. A continuación, el profesor (el mismo en ambos grupos) explicó los fundamentos teóricos de la POO (clases, métodos y atributos) y la sintaxis básica de Java (sentencias de clases y atributos, operadores aritméticos, entrada y salida), utilizando VILEP específica para cada uno. Posteriormente en el GE se utilizó VILEP y en el GC se utilizó Eclipse para desarrollar el primer programa con la asesoría del docente. A continuación, ambos grupos realizaron varias pruebas implementando un programa Java básico, el GE utilizando VILEP mediante programación visual y el CG utilizando Eclipse con programación textual clásica. La Figura 2 muestra un programa desarrollado por estudiantes de GE usando VILEP. Finalmente, se reevaluaron los conocimientos y las emociones tras la realización de la tarea.

VII. Resultados

En primer lugar se muestra la estadística descriptiva de los datos recopilados sobre conocimiento y emociones (ver Tabla I). Analizando las emociones positivas en el grupo experimentaly el de control, se puede observar que existe un incremento en las emociones experimentadas al inicio de la experiencia en ambos grupos. Sin embargo, las emociones positivas son mayores en el grupo de experimental respecto al grupo de control. También se puede observar que al finalizar la experiencia las emociones negativas experimentas por GE tiene una reducción mayor que en el grupo de control.

Así también con respecto a los resultados en el nivel de conocimiento se observa que existe un incremento de conocimiento en los dos grupos, siendo mayor en el grupo de control. Estos resultados se pueden entender debido al uso de la programación visual con VILEP fomenta las emociones positivas de algunos estudiantes en el proceso de aprendizaje de la programación y a que permite que el estudiante se centre únicamente en los conceptos y estructuras de la programación durante el proceso de aprendizaje.

Tabla I. Resultados descriptivo de los grupos de trabajo

	GRUPO	N.	MEDIA
CONOCIMIENTO_PRE	GC	17	3,44
	GE	21	3,85
CONOCIMIENTO_POS	GC	17	3,7
	GE	21	4,03
EMO_POS_PRE	GC	17	36,24
	GE	21	38,71
EMO_POS_POS	GC	17	36,53
	GE	21	39,67
EMO_NEG_PRE	GC	17	15.82
	GE	21	14.76
EMO_NEG_POS	GC	17	15.29
	GE	21	13.76

En relación con la usabilidad, como ya se ha comentado anteriormente, se ha aplicado al grupo experimental el test SUS (System Usability Scale). Sin embargo, los resultados hay que leerlos considerando que existe cierta subjetividad, ya que se pregunta por la percepción y esta varía en función de cada usuario. Después de calificar el test se determinó que el valor promedio de todos los resultados de los usuarios que emplearon VILEP fue de 68.25. Esto es un valor ligeramente superior al promedio estándar de 68, por debajo del cual se considera que la aplicación presenta deficiencias desde el punto de vista de la usabilidad. Por tanto, se puede considerar que VILEP presenta una usabilidad aceptable. Un resultado por debajo de esta cifra indicaría que hay varios aspectos a corregir.

Tabla II. Resultados del test de usabilidad

P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**	**P10**
5	1	3	1	1	1	5	1	5	4
5	1	3	1	5	2	5	1	5	1
3	3	3	5	5	3	3	3	3	5
4	4	2	2	4	2	2	4	2	5
4	5	3	3	3	4	5	2	3	5
4	1	1	1	5	1	5	3	4	2
4	3	1	3	3	4	1	1	3	4
4	2	4	3	4	2	4	3	4	4
3	2	2	2	5	1	5	3	5	3
4	1	4	1	5	1	5	1	5	4
4	1	3	1	4	1	4	1	1	2
4	**2,18**	**2,63**	**2,09**	**4**	**2**	**4**	**2,09**	**3,63**	**3,54**

VIII. CONCLUSIONES

Según los resultados obtenidos en la comparación entre el GE que utilizó VILEP y el GC que utilizó el Eclipse IDE, se observó que VILEP ofrece beneficios en términos de emocionespositivas y conocimientos adquiridos.

Se observa un aumento en la motivación y emociones positivas en el grupo experimental en comparación con el grupo de control, esto sugiere que VILEP y su enfoque de Scaffolding pueden tener un impacto positivo en el compromiso y la satisfacción de los estudiantes durante el proceso de aprendizaje.

El GE demuestra un mayor incremento en los conocimientos adquiridos en comparación con el grupo de control, esto indica que VILEP diseñada puede facilitar una comprensión más profunda de los conceptos y del lenguaje de programación.

Como trabajos futuros se abren las siguientes líneas: (a) Evaluación a largo plazo: Para comprender mejor el impacto a largo plazo de VILEP, sería beneficioso realizar un seguimiento de los estudiantes después de la experiencia y evaluar su desempeño y retención de conocimientos en etapas posteriores;

(b) Personalización y adaptabilidad: Mejorar la personalización de VILEP para adaptarse a las necesidades y estilos de aprendizaje individuales de los estudiantes, permitiendo que se presenten distintos niveles de Scaffolding; (c) Evaluación estadística: Realizar análisis estadístico para identificar posibles correlaciones; y (d) Inclusión de otras métricas: Inclusión de otras métricas relevantes, como la eficiencia en la resolución de problemas o el nivel de confianza en la programación, puede proporcionar una visión más completa del impacto de VILEP.

ACKNOWLEDGMENT

Este trabajo ha sido financiado por al proyecto e-Madrid (Ref. P2018/TCS-4307) con fondos FSE y FEDER; y por la Universidad de las Fuerzas Armadas ESPE grant 2022-EXT-003 ESPE junto a la Universidad Tecnológica Indoamérica a través del proyecto “Cyber-Physical Systems for Smart Environments- SCEIN” con fondos INV-0012-031.

REFERENCES

[1] O. P. Shefer, L. S. Nosova, and T. N. Lebedeva, “A Modern Methodology for Teaching Programming at a University,” *Scientific and Technical Information Processing*, vol. 45, no. 2, pp. 81–86, Apr. 2018..

[2] C. E. M. Marín, P. A. G. García, J. M. C. Lovelle, and O. S. Martínez, “Application of model-driven engineering (MDA) for the construction of a tool for domain-specific modeling (DSM) and the creation of modules in learning management systems (LMS) platform independent,” *DYNA (Colombia)*, vol. 78, no. 169, pp. 43–52, 2011.

[3] D. Giraldo, W. J. Giraldo, and S. Espa, “Considerations about quality in model-driven engineering,” pp. 685–750, 2018.

[4] S. Barzilai and I. Blau, “Scaffolding game-based learning: Impact on learning achievements, perceived learning, and game experiences,” *Comput Educ*, vol. 70, pp. 65–79, 2014.

[5] C. H. Chen and V. Law, “Scaffolding individual and collaborative game-based learning in learning performance and intrinsic motivation,” *Comput Human Behav*, vol. 55, pp. 1201–1212, Feb. 2016.

[6] J. Van de Pol, M. Volman, and J. Beishuizen, “Scaffolding in Teacher–Student Interaction: A Decade of Research,” *Educ Psychol Rev*, vol. 22, no. 3, 2010.

[7] M. Siadaty, D. Gašević, and M. Hatala, “Associations between technological Scaffolding and micro-level processes of self-regulated learning: A workplace study,” *Comput Human Behav*, vol. 55, pp. 1007–1019, 2016.

[8] E. Delen, J. Liew, and V. Willson, “Effects of interactivity and instructional Scaffolding on learning: Self-regulation in online video-based environments,” *Comput Educ*, vol. 78, pp. 312–320, 2014.

[9] A. Deublein, A. Pfeifer, K. Merbach, K. Bruckner, C. Mengelkamp, and B. Lugrin, “Scaffolding of motivation in learning using a social robot,” *Comput Educ*, vol. 125, pp. 182–190, Oct. 2018.

[10] E. Haataja, E. Garcia Moreno-Esteva, V. Salonen, A. Laine,
M. Toivanen, and M. S. Hannula, “Teacher’s visual attention when Scaffolding collaborative mathematical problem solving,” *Teach Teach Educ*, vol. 86, p. 102877, 2019.

[11] J. G. López Solórzano and C. J. Ángel Rueda, “Revisión sistemática de los entornos digitales inmersivos tridimensionales en la enseñanza de la programación,” *Revista de Educación a Distancia (RED)*, vol. 23, no. 73, Jan. 2023.

[12] B. R. Belland, “Scaffolding: Definition, Current Debates, and Future Directions,” in *Handbook of Research on Educational Communications and Technology*, J. M. Spector, M. D. Merrill, J. Elen, and M. J. Bishop, Eds., New York, NY: Springer New York, 2014, pp. 505–518.

[13] T. Nousiainen, M. Kangas, J. Rikala, and M. Vesisenaho, “Teacher competencies in game-based pedagogy,” *Teach Teach Educ*, vol. 74, pp. 85–97, 2018.

[14] G. Md. M. Bashir and A. S. Md. L. Hoque, “An effective learning and teaching model for programming languages,” *Journal of Computers in Education*, vol. 3, no. 4, pp. 413–437, 2016.

[15] H. Abas and H. B. Zaman, “Scaffolding models for remedial students in using augmented reality storybook,” *Proceedings of the 2011 International Conference on Electrical Engineering and Informatics, ICEEI 2011*, no. July, 2011.

[16] J. Nó and F. Galindo, “Scaffolding en microformación a través de audiovisual personalizado para dispositivos móviles,” *SIECCI Simposium Iberoamericano en Educación, Cibernética e Informática*, vol. 1, p. 5, 2009.

[17] L. Sun, H. Ruokamo, P. Siklander, B. Li, and K. Devlin, “Primary school students’ perceptions of Scaffolding in digital game-based learning in mathematics,” *Learn Cult Soc Interact*, vol. 28, Mar. 2021.

[18] R.-E. Ibarra-Zapata, J.-O. Castillo-Cornelio, P.-C. Trujillo- Natividad, C. García-Villegas, R. Yanac-Montesino, and B. Pando, “Enseñanza-aprendizaje de programación de computadoras: avances en la última década,” *Revista Científica*, vol. 42, no. 3, pp. 290–303, Sep. 2021.

[19] A. Steinmann, B. Bosch, and D. Aiassa, “Motivación y expectativas de los estudiantes por aprender ciencias en la universidad: Un estudio exploratorio,” *Revista Mexicana de Investigacion Educativa*, vol. 18, no. 57, pp. 585–598, 2013.

[20] R. Vallerand, “The academic motivation scale: a measure of intrinsic, extrinsinc, and amotivation in education,” *Educ Psychol Meas*, vol. 52, pp. 1003–1017, 1992.

[21] C. Kazimoglu, M. Kiernan, L. Bacon, and L. Mackinnon, “A Serious Game for Developing Computational Thinking and Learning Introductory Computer Programming,” *Procedia Soc Behav Sci*, vol. 47, pp. 1991–1999, 2012.

ESQUEMAS DE METADATOS RECONFIGURABLES CON ELEMENTOS MULTIVALUADOS: HACIA LA GESTIÓN DE REPOSITORIOS EDUCATIVOS MEDIANTE GRAMÁTICAS FORMALES EN LA PLATAFORMA CLAVY

(Reconfigurable Metadata Schemas with Multivalued Elements: Towards Learning Object Repository Management Using Formal Grammars in the *Clavy* platform)

Joaquín Gayoso-Cabada
Escuela Técnica Superior de Ingeniería de Sistemas Informáticos
Universidad Politécnica de Madrid
Madrid, España
j.gayoso@upm.es

Mercedes Gómez-Albarrán
Facultad de Informática
Universidad Complutense de Madrid
Madrid, España
mgomeza@ucm.es

José-Luis Sierra
Facultad de Informática
Universidad Complutense de Madrid
Madrid, España
jlsierra@ucm.es

Resumen—Clavy es una plataforma experimental para la gestión de repositorios educativos que permite definir esquemas de metadatos específicos para cada dominio didáctico, e incluso para cada repositorio particular. Así mismo, Clavy también permite reconfigurar dinámicamente dichos esquemas para modificar la forma en la que se exploran y se visualizan los objetos didácticos. En este artículo motivamos y detallamos la evolución sufrida por el modelo de esquemas de metadatos de Clavy para soportar elementos descriptivos multivaluados. Así mismo, caracterizamos dicha extensión como un tipo restringido de formalismo gramatical, lo que abre la posibilidad de utilizar gramáticas más generales para organizar los contenidos de los repositorios.

Palabras clave— Repositorios de objetos educativos, Esquemas de Metadatos

***Abstract-Clavy* is an experimental platform for learning object repository management that allows defining specific metadata schemas for each didactic domain, and even for each particular repository. *Clavy* also makes it possible to dynamically reconfigure these schemas to modify the way in which learning objects are explored and visualized. In this paper we motivate and detail the evolution of *Clavy*'s metadata schema model to support multivalued descriptive elements. We also characterize this extension as a restricted type of grammatical formalism, which opens the possibility of using more general grammars to organize repository contents.**

Keywords- Learning Object Repositories, Metadata Schemas

I. INTRODUCCIÓN

Clavy [2] es una plataforma experimental de gestión de repositorios de objetos educativos que hemos estado desarrollando durante la última década en la Universidad Complutense de Madrid (UCM) [1][2]. La plataforma, a su vez, es una evolución de la plataforma OdA desarrollada anteriormente también en la UCM [3]. Algunos de los principales avances de *Clavy* frente a OdA son: (i) un modelo de metadatos más expresivo; (ii) mecanismos de navegación, edición y visualización más elaborados; (iii) incorporación de un enfoque ETL (*Extract-Transform-Load*) que facilita la interconexión del sistema con una amplia variedad de fuentes externas de información; y (iv) mecanismos de implementación más eficientes que, entre otras características, proporcionan soporte eficiente a la reconfiguración dinámica de los repositorios [4].

Una de las principales características de *Clavy*, característica compartida con la plataforma predecesora OdA, es permitir definir esquemas de metadatos específicos para cada dominio de aprendizaje concreto, e incluso para cada repositorio particular. De esta forma, en lugar de adoptar un esquema de metadatos pre-establecido (v.g., LOM [5]), *Clavy* soporta la definición inductiva de los esquemas que mejor se acomodan a cada escenario particular. Estos esquemas, de forma innovadora, se definen y reconfiguran conforme se construyen y evolucionan los objetos de los repositorios. En la UCM hemos podido comprobar la utilidad de este enfoque mediante la aplicación de *Clavy* a distintos dominios altamente especializados, tanto en el campo de las humanidades (biblioteca *Mnemosine* [3] sobre textos raros y olvidados de la Edad de Plata en España [6] y biblioteca Ciberia [4] sobre literatura digital en Español [7]), el de la lingüística (diccionarios didácticos de Latín y Alemán [8] [5]), y el de las ciencias de la salud (repositorio basado en la biblioteca MedPix sobre educación en radiología [1] [6]).

En este artículo describimos la evolución sufrida por el modelo de definición y gestión de esquemas de metadatos en *Clavy* para soportar elementos multivaluados. Para ello comenzamos describiendo la versión inicial de dicho modelo, basado en organizaciones jerárquicas de elementos (sección II). Seguidamente motivamos la necesidad de elementos multivaluados (sección III). A continuación, describimos la evolución del modelo para soportar este tipo de elementos (sección IV). La sección V discute algunas de las limitaciones que persisten en el modelo resultante, reinterpreta el modelo resultante como un tipo restringido de formalismo gramatical, y propone el uso de gramáticas más generales para resolver las limitaciones indicadas. El artículo termina con una sección de conclusiones y posibles líneas de trabajo futuro (sección VI).

2 http://clavy.fdi.ucm.es

3 http://repositorios.fdi.ucm.es/mnemosine/

4 http://repositorios.fdi.ucm.es/ciberia/

5 http://repositorios.fdi.ucm.es/DiccionarioDidacticoLatin, http://repositorios.fdi.ucm.es/DiccionarioDidacticoAleman

6 http://clavy.fdi.ucm.es:8080/Clavy/?idref=clavy.fdi.ucm.es/c54

II. ESQUEMAS DE METADATOS COMO ORGANIZACIONES JERÁRQUICAS RECONFIGURABLES

La versión inicial del modelo de metadatos en *Clavy* se basa en la propuesta de la plataforma predecesora OdA, y concibe los esquemas de metadatos como organizaciones jerárquicas de *elementos* [9]. Cada uno de estos elementos puede ser de tres tipos diferentes:

- Elementos *descriptivos*. Estos elementos están dirigidos a describir distintos aspectos del objeto educativo.
- Elementos *estructurales*. Estos elementos sirven como meros contendedores de otros elementos.
- Elementos de *enlace*. Estos elementos permiten enlazar objetos entre sí, expresando, de esta forma, relaciones semánticas entre objetos.

La Fig. muestra un ejemplo muy simple de esquema en el dominio de la literatura[7]. Dicho esquema permite describir objetos asociados con *obras literarias*. El elemento estructural *Obra* agrupa el *Título* y el *Contribuyente* de la obra (ambos elementos descriptivos). El elemento descriptivo *Rol* (hijo de *Contribuyente*) permite, por su parte, indicar si el contribuyente es *autor*, *editor*, *prologuista*, etc.

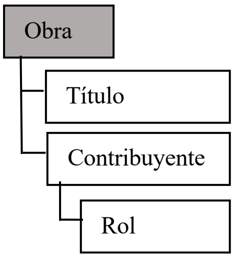


Fig. 1. Un esquema muy simple en el dominio de la literatura.

El modelo de metadatos permite, además, *reconfigurar* el esquema. En particular, es posible cambiar la filiación de los elementos en la jerarquía, lo que, a su vez, afecta a la forma en la que se visualizan los objetos, así como a la forma en la que se navega por el repositorio. En [9][10][11][12] se discuten distintos mecanismos para soportar eficientemente la reconfiguración.

III. La NECESIDAD DE ELEMENTOS MULTIVALUADOS

Conforme utilizamos el modelo de metadatos básico descrito en la sección anterior en los escenarios ya citados anteriormente (bibliotecas digitales *Mnemosine* y *Ciberia*, diccionarios didácticos, repositorios educativos en radiología), pronto fuimos conscientes de sus limitaciones. De éstas, la más crítica fue la referente al tratamiento de la *variabilidad*.

Las limitaciones del modelo básico para tratar con la variabilidad se pueden ilustrar con el esquema de la Fig. . Si, como resulta habitual, necesitamos describir *obras* que tengan, no uno, sino dos, tres, cuatro, etc. contribuyentes, con el modelo básico necesitaremos incluir tantos elementos *Contribuyente* al esquema como sea necesario, dependiendo de los contenidos particulares a catalogar, y luego utilizar los que sean necesarios en la descripción de cada obra particular. No obstante, este tipo de solución de duplicar estructura pronto se revela inviable, ya que cada elemento puede tener asociada, a su vez, toda una subjerarquía de elementos de más bajo nivel que debe ser duplicada con cada nueva versión del elemento. En el ejemplo, con cada *contribuyente* incorporado, debería incorporarse también un elemento *Rol* (Fig.). En este caso el esfuerzo es abordable, pero si, en lugar de tener una subjerarquía con un único elemento, tuviéramos una subjerarquía más frondosa[8], la complejidad de la tarea aumentaría significativamente. La inclusión de elementos multivaluados surge, entonces, para solventar esta limitación.

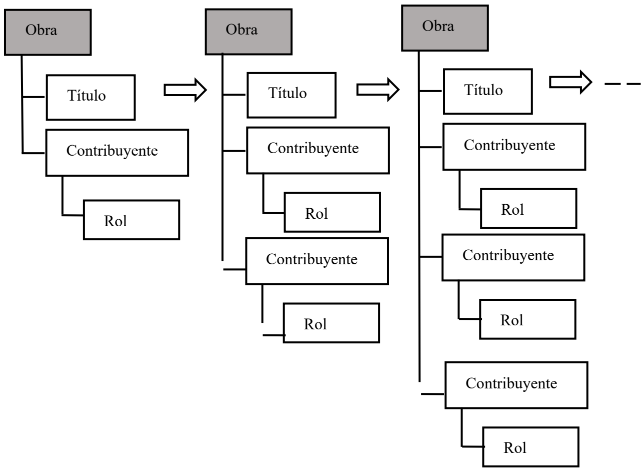


Fig. 2. Inclusión de varios *contribuyentes* en el esquema de la Fig. .

IV. EXTENSIÓN DEL MODELO CON ELEMENTOS MULTIVALUADOS

En esta sección describimos la extensión del modelo básico introducido en la sección II con elementos multivaluados. La subsección I.A describe el modelo resultante. La subsección I.B analiza las implicaciones relativas a la reconfiguración. La subsección I.C analiza, por último, las implicaciones del modelo en la organización del repositorio.

A. Esquemas con atributos multivaluados

Los esquemas de metadatos en el modelo extendido consisten, al igual que en el modelo básico, en organizaciones jerárquicas de elementos. La principal diferencia es que, ahora, los elementos pueden ser *simples* (ocurren una única vez en el etiquetado de los objetos), o *multivaluados* (pueden ocurrir varias veces). De esta forma, un elemento multivaluado permite utilizar, en el etiquetado del objeto, tantos ejemplares de la subjerarquía enraizada en el mismo como sean necesarios.

Por tanto, en el ejemplo que estamos considerando, *Contribuyente* puede caracterizarse como un elemento multivaluado. La Fig. (a) muestra un esquema que aprovecha esta característica: la única diferencia con el esquema en la Fig. es el carácter multivaluado de *Contribuyente* (se marca con *). La Fig. (b) esboza, por su parte, un pequeño repositorio etiquetado con este esquema. Obsérvese que la obra "*Las cenizas*" tiene un único elemento *Contribuyente*, mientras que la obra "*Las maderas*" tiene dos elementos *Contribuyente*, cada uno de ellos jugando un *Rol* diferente.

7 Este esquema está adaptado de uno de los fragmentos utilizados en *Mnemosine*.

8 Este fue el caso, por ejemplo, con los diccionarios didácticos de Latín y Alemán.

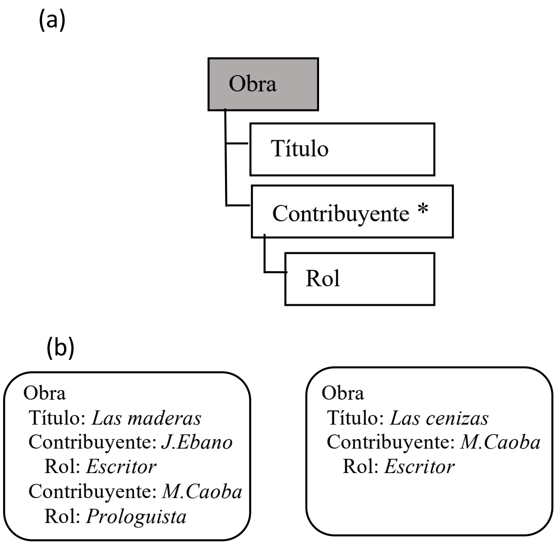


Fig. 3,. (a) Refactorización del esquema de la Fig. con un elemento *Contribuyente* multivaluado; (b) ejemplo de pequeño repositorio.

B. Reconfiguración de esquemas con elementos multivaluados

Mientras que en el modelo básico las organizaciones jerárquicas de elementos pueden reorganizarse de manera arbitraria, ya que cada elemento ocurre una única vez en la descripción de cada objeto, en el caso de esquemas con elementos multivaluados la reconfiguración no es tan evidente. Efectivamente:

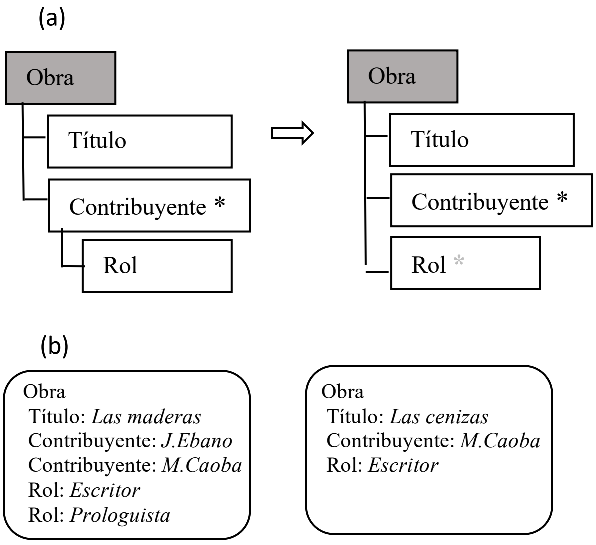


Fig 4. Hipotética reconfiguración que extrae un hijo de un elemento multivaluado de su contexto (a), y su efecto en el repositorio (b).

- Si se permitiera que un elemento *e* en la subjerarquía enraizada en un elemento multivaluado *m* se desplazara fuera de dicha subjerarquía, *e* en sí pasaría a ser multivaluado. Además, en cada documento, cada uno de los ejemplares de *e* perdería el contexto fijado por cada uno de los ejemplares de *m*. Para ilustrar esta problemática, consideremos, por ejemplo, el esquema de la Fig. (a), y supongamos que deseamos que *Rol* aparezca ahora, no como hijo de *Contribuyente*, sino como hijo de *Obra*. Dado que, en el esquema original, *Rol* es hijo de *Contribuyente*, que, a su vez, es multivaluado, al realizar esta reconfiguración, *Rol* debería pasar a ser multivaluado (Fig(a)). Por su parte, en cada objeto aparecerían los ejemplares de *Rol* en los objetos del repositorio original, pero esta vez situados bajo *Obra*, sin ningún tipo de información que indique a qué contribuyente está asociado cada rol (Fig(b)).

- Si, por el contrario, se permitiera que un elemento *e*, situado fuera de la subjerarquía de un elemento multivaluado *m*, ingresara en dicha subjerarquía, sería necesario decidir cómo contextualizar dicho elemento (es decir, bajo qué ejemplar de *m* situarlo en cada documento de metadatos). La cuestión se complica todavía más cuando *e* es, en sí, multivaluado. Una posibilidad sería situar una copia de *e* bajo cada ejemplar de *m*, pero esta solución no deja de ser un mero artificio, que no tiene en cuenta ningún tipo de consideración de contextualización. Para ilustrar este hecho, supongamos, ahora, que en el esquema que resulta en la Fig, volvemos a poner *Rol* como hijo de *Contribuyente*, para intentar recuperar el esquema original en la Fig. . Sin embargo, bajo esta solución, este intento sería imposible, ya que *Rol* es ya un atributo multivaluado. El esquema resultante sería, por el contrario, el mostrado en la Fig. (a), y el efecto en el repositorio de la Fig(b) el mostrado en la Fig. (b), efecto, a todas luces, indeseado. Aparte de ello, debe tenerse en cuenta que, ante la presencia de múltiples elementos multivaluados anidados, el artificio podría originar un incremento exponencial en el tamaño de los objetos.

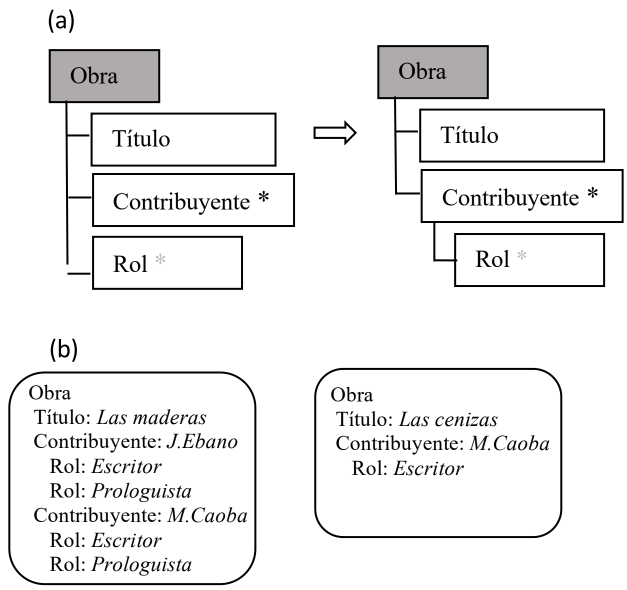


Fig. 5. Hipotética reconfiguración que inserta un elemento como hijo de uno multivaluado (a), y su efecto en el repositorio (b).

Estas consideraciones ponen de manifiesto que, en general, las reconfiguraciones que suponen extraer elementos fuera del contexto de elementos multivaluados, o ingresarlos dentro del contexto de dichos elementos, carecen de sentido. Es por ello que *Clavy* prohíbe este tipo de reconfiguraciones, permitiendo únicamente reorganizar estructuras dentro de sus respectivos contextos. Así, en el esquema de la Fig. (a) será posible poner *Contribuyente* como hijo de *Título* si así se desea, pero, en ningún caso, se permitirá extraer *Rol* fuera del contexto de *Contribuyente*, o poner *Título* como hijo de *Contribuyente*.

C. Organización de los repositorios

La introducción de elementos multivaluados tiene un impacto significativo en la organización interna de los repositorios. Efectivamente, y tal y como se describe en [9], con el fin de adaptarse al carácter reconfigurable de los esquemas, en el modelo básico los objetos se representan como conjuntos de pares *elemento – valor*, indicando el valor para cada elemento *descriptivo* o *de enlace*. El esquema puede utilizarse, entonces, para reorganizar dicho conjunto cuando el objeto se visualiza (añadiendo, además, los elementos estructurales necesarios). Con ello, si el esquema se reconfigura, no es necesario reconfigurar cada uno de los objetos individuales.

Sin embargo, esta representación, por sí sola, deja de tener sentido cuando el esquema se extiende con elementos multivaluados, ya que estos elementos pueden exhibir más de un valor. Podría pensarse, entonces, en asociar con cada elemento multivaluado el conjunto de todos sus valores, pero, aún en dicho supuesto, la representación resultante sigue siendo insuficiente para manejar elementos multivaluados. Para apreciar este hecho, considérese esta representación conjuntista para el objeto asociado a la obra "*Las maderas*" en la Fig. (b), tal y como muestra la Fig. : considerando únicamente el esquema y esta representación es imposible decidir qué *Rol* se corresponde con qué *Contribuyente*. En otras palabras, el esquema y los conjuntos de pares *elemento – valor*, por sí solos, no permiten contextualizar adecuadamente los descendientes de los elementos multivaluados.

Título: *Las maderas*
Contribuyente: {*J.Ebano*, *M.Caoba*}
Rol: {*Escritor*, *Prologuista*}

- Fig. 6. Hipotética representación conjuntista de un objeto con elementos multivaluados.

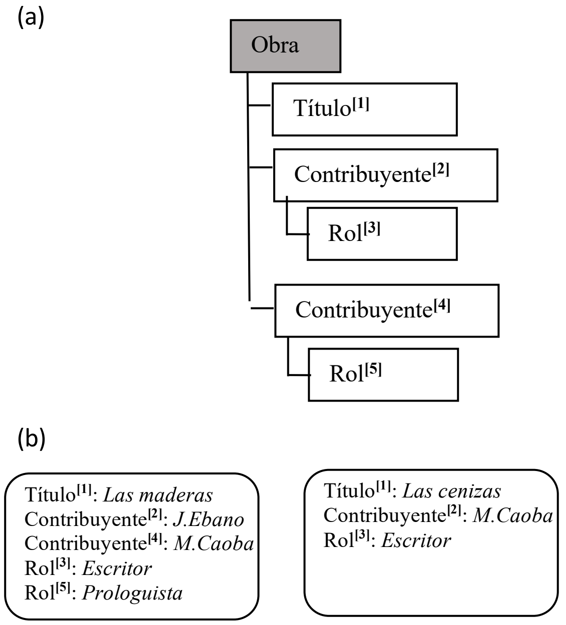
Para solucionar este problema es posible:

- Mantener automáticamente, como estructura intermedia, la jerarquía básica de elementos instanciados para catalogar los distintos objetos. Dicha estructura será, en realidad, un esquema conforme con el modelo básico introducido en la sección II, y se denominará *estructura básica* del repositorio.

- Representar los objetos como conjuntos de pares *elemento – valor* sobre la estructura básica.

Obsérvese que, a pesar de que, en la estructura básica, los elementos tengan el mismo nombre, cada uno de estos elementos tendrá, internamente, un identificador único (lo mismo que ocurre, de hecho, con el modelo básico descrito en la sección II). De esta forma, la estructura básica podrá utilizarse para contextualizar adecuadamente los elementos de los objetos. La Fig. ilustra esta organización en el caso del repositorio de la Fig. . En los elementos de la estructura básica se añaden explícitamente identificadores únicos. De esta forma, resulta evidente cómo, utilizando la estructura básica es posible *ensamblar* adecuadamente los objetos a partir de sus representaciones conjuntistas, sin más que poblar cada elemento *descriptivo* y *de enlace* de la estructura con los valores tomados de los respectivos conjuntos.

Obsérvese, por último, que, cada vez que se reconfigure el esquema, bastará reconfigurar únicamente la estructura básica, en lugar de tener que reconfigurar cada uno de los objetos individuales. Dicha reconfiguración se lleva a cabo automáticamente, de forma transparente para el usuario.



- Fig.7. Estructura básica para el repositorio de la Fig. y representación conjuntista asociada.

V. DISCUSIÓN: GRAMÁTICAS FORMALES COMO ESQUEMAS DE METADATOS

En esta sección se comienza analizando algunas limitaciones que persisten en el modelo de metadatos descrito en la sección anterior (subsección I.D). Seguidamente se caracteriza dicho modelo como un tipo muy limitado de gramática EBNF[9] (subsección I.E), y se discute su extensión a gramáticas EBNF generales con el fin de subsanar las limitaciones indicadas (subsección I.F).

D. Limitaciones del modelo de metadatos Clavy

A pesar de que la inclusión de elementos multivaluados ha mejorado significativamente la utilidad práctica del enfoque, los esquemas de catalogación en *Clavy* continúan presentando otras limitaciones expresivas, que se han puesto en evidencia durante las experiencias aludidas en la sección I, y que, si bien no son tan críticas como las descritas en la sección III, sí merecen atención adicional:

- Los esquemas *Clavy* carecen de estructuras alternativas, lo que, a su vez, limita la caracterización de la variabilidad. De esta forma, en las propuestas que hemos desarrollado hasta el momento, la variabilidad que no puede ser directamente abordada mediante el uso de elementos multivaluados se ha abordado proponiendo múltiples esquemas alternativos, uno por cada variante. Esto sucede, por ejemplo, con el concepto *Obra* en el repositorio *Mnemosine* donde los

9 Una gramática EBNF es una generalización de las *gramáticas incontextuales*. Una gramática incontextual especifica las construcciones sintácticas de un lenguaje mediante *reglas* de la forma $A \rightarrow \alpha$, donde A es un *no terminal* (modela una construcción sintáctica compuesta) y α es una cadena de *no terminales* y *terminales* (los terminales modelan elementos básicos del lenguaje). Las gramáticas EBNF extienden este modelo permitiendo *expresiones regulares* arbitrarias en las partes derechas de las reglas. A su vez, las expresiones regulares describen patrones de cadenas utilizando operadores tales como • para concatenar patrones (normalmente se omite), | para especificar la unión de patrones, y * para especificar la repetición. Para una descripción más detallada de estos artefactos puede consultarse, por ejemplo, [13].

expertos han propuesto hasta diez esquemas alternativos para objetos de tipo *Obra*, conteniendo cada uno de ellos pequeñas variaciones que, sin embargo, son imposibles de capturar actualmente por *Clavy* en un único esquema.

- Los esquemas *Clavy* también carecen de mecanismos de *abstracción*, que permitan abstraer y reutilizar una misma estructura en múltiples contextos. Esta carencia se observa, por ejemplo, también en *Mnemosine*, donde se definen distintos tipos de *actores*, muchos de los cuáles comparten atributos comunes cuya caracterización, sin embargo, debe replicarse.

- Por último, y como consecuencia directa de la carencia de mecanismos de abstracción, los esquemas *Clavy* no pueden basarse en definiciones recursivas. Este hecho limita la capacidad expresiva del formalismo (v.g., en *Clavy* no puede definirse un esquema para caracterizar, por ejemplo, *documentos* como secuencias de *párrafos*, que pueden contener *textos*, y, a la vez, otros *párrafos*, ya que una definición de este tipo es intrínsecamente recursiva).

E. *Esquemas* Clavy *como gramáticas formales*

Para abordar las limitaciones de los esquemas *Clavy* comenzaremos caracterizando estos como un tipo muy limitado de gramática formal. Para ello, podemos comenzar enfatizando la analogía entre los elementos multivaluados en los esquemas *Clavy* y el mecanismo de *cierre de Kleene* (operador de repetición *) en la formulación de *expresiones regulares* [13]. En este sentido, un esquema *Clavy* puede entenderse como:

- Un *alfabeto de elementos*, en el que se enumera los elementos del esquema, su carácter (*univaluado*, *multivaluado*), y su tipo (*estructural*, *descriptivo*, *enlace*).

- Una expresión regular sobre los elementos del alfabeto de elementos.

- Una relación jerárquica entre elementos. Dicha relación puede reorganizarse, siempre y cuando se respeten las restricciones indicadas en la subsección I.B (es decir, siempre y cuando no se extraigan elementos del contexto de elementos multivaluados, ni se ingresen elementos en dichos tipos de contextos).

La expresión regular constituye, en sí, el componente esencial del esquema. Para caracterizar esta expresión, podemos obtener la expresión regular asociada a cada nodo raíz del esquema (i.e., cada tipo de objeto). En esquemas complejos, que involucren distintos tipos de objetos, la expresión regular se obtendrá mediante la disyunción de las expresiones asociadas con cada tipo de objeto. Por su parte, para obtener la expresión regular asociada a un nodo n que tiene una secuencia de hijos (posiblemente vacía) $h_1 \ldots h_k$ ($k \geq 0$):

- Si $k > 0$, comenzaremos obteniendo las expresiones regulares $E_1 \ldots E_k$ asociadas con cada hijo.

- Si el elemento e asociado a n es univaluado: (i) si $k = 0$, entonces la expresión regular asociada a n será e; (ii) si $k > 0$, entonces, la expresión regular será $e\ E_1 \ldots E_k$.

- Si el elemento e es multivaluado: (i) si $k = 0$, entonces la expresión regular será e*; (ii) si $k > 0$, entonces la expresión regular será $(e\ E_1 \ldots E_k)$*.

Por ejemplo, la expresión regular asociada al esquema de la Fig. (a), donde hay un único tipo de objetos, es:

`Obra Titulo (Contribuyente Rol)*` **(1)**

Por su parte, la estructura básica del repositorio puede entenderse como la unión de los *árboles de derivación* de los distintos documentos con respecto a la expresión regular asociada al esquema (véase, por ejemplo, [14] para el concepto de *árbol de derivación* asociado a una expresión regular), reorganizada de acuerdo con las relaciones jerárquicas entre elementos, y con el carácter univaluado o multivaluado de los mismos.

Una vez caracterizado el esquema como una expresión regular, el paso a una gramática formal es directo: basta introducir una única regla EBNF, cuya parte izquierda sea el símbolo de inicio de la gramática, y cuya parte derecha sea la expresión regular. Por ejemplo, en el esquema de la Fig. (a):

`EObra` `→ Obra Titulo (Contribuyente Rol)*` **(2)**

F. *Gramáticas* EBNF *como esquemas de metatados*

La caracterización gramatical de los esquemas de metadatos *Clavy* abre la posibilidad a extender los mismos para cubrir gramáticas EBNF más generales, de forma similar a como ocurre, por ejemplo, en la definición de la estructura de documentos en lenguajes de marcado generalizado (v.g, XML) [15]. De esta forma:

- En lugar de utilizar únicamente las operaciones de concatenación y *cierre de Kleene* en la formulación de expresiones regulares, es posible plantear el uso de otras operaciones, y, en particular, el uso de la alternancia. Esto permitirá mejorar la capacidad de tratamiento de la variabilidad del formalismo. Así mismo, y aparte de las operaciones básicas utilizadas en el formalismo de las expresiones regulares, es posible incluir otras operaciones derivadas (v.g, el cierre positivo +, para indicar una o más ocurrencias de cierta estructura, o la opcionalidad ?, para indicar ocurrencia o no ocurrencia).

- En lugar de una única regla, es posible disponer de múltiples reglas asociadas a distintos no terminales, que, a su vez, puedan utilizarse en múltiples contextos. Esto permitirá abordar de manera natural la limitación de abstracción del formalismo actual.

- El uso no restringido de EBNF permitirá, así mismo, incorporar de manera natural la recursión en el formalismo, aumentando, de esta forma, substancialmente su poder expresivo. La Fig. 4 ejemplifica este hecho con la formulación de un esquema para los *documentos* a los que se ha hecho alusión en la subsección I.D como una gramática EBNF (los símbolos no terminales aparecen en cursiva, mientras que los elementos aparecen en negrita).

- *`Documento`* → **`doc`** *`Contenido+`*
- *`Contenido`* → **`texto`** | *`Parrafo`*
- *`Parrafo`* → **`par`** *`Contenido+`*

- Fig. 4. Caracterización de un esquema para *documentos* mediante una gramática EBNF.

Estas gramáticas pueden, a su vez, coexistir con la relación jerárquica entre elementos, relación que, bajo ciertas limitaciones, podrá reconfigurarse. Al igual que en el modelo actual los elementos multivaluados fijan barreras al ingreso y la extracción de elementos durante la reconfiguración, en el modelo basado en gramáticas EBNF generales dichas barreras vendrán impuestas por las operaciones de *cierre de Kleene* y de alternancia, ya que dichas construcciones establecen contextos locales para los distintos tipos de elementos.

Es interesante analizar también el papel de los elementos multivaluados en esta generalización: dado que ahora aparece explícitamente la operación de *cierre de Kleene*, el carácter multivaluado de los elementos deja de tener sentido. En su lugar, podrá emplearse el *cierre de Kleene* sobre elementos, o, en general, sobre estructuras más complejas, como ocurre en el formalismo de las expresiones regulares.

Finalmente, y en lo relativo a la organización externa del repositorio, ésta seguirá un enfoque similar al implementado actualmente en *Clavy*. Para ello, se mantendrá explícitamente la estructura básica de los objetos como la unión de los árboles de derivación de los objetos del repositorio, reorganizada de acuerdo con la organización jerárquica de elementos, y dicha estructura se utilizará para interpretar cada uno de estos objetos (dichos objetos continuarán almacenándose, por su parte, como conjuntos de pares *elemento – valor*).

VI. CONCLUSIONES Y TRABAJO FUTURO

En este artículo hemos descrito la evolución basada en elementos multivaluados del modelo de metadatos utilizado en la plataforma experimental *Clavy* para la gestión de repositorios didácticos con estructuras dinámicamente reconfigurables. El uso de elementos multivaluados ha permitido abordar la formulación inductiva de esquemas de catalogación para repositorios, formulación que hubiera resultado inviable mediante el uso del modelo básico. Efectivamente, al carecer de este tipo de elementos, el modelo básico obligaba a representar explícitamente tantas copias de los elementos que se repetían como se estimaran necesarias para describir los objetos del repositorio. En el artículo hemos analizado, así mismo, las dificultades de reconfiguración de esquemas que introduce el modelo resultante, hemos justificado la limitación de dichas reconfiguraciones a los contextos establecidos por los elementos multivaluados, y hemos descrito las implicaciones en la organización interna de los repositorios, organización que puede articularse satisfactoriamente mediante el mantenimiento automático de la estructura básica utilizada hasta el momento. Así mismo, y aunque el modelo ha resultado útil en la práctica para abordar el desarrollo de distintos repositorios en dominios reales, hemos detectado también distintas limitaciones relativas al manejo de la variabilidad, a los mecanismos de abstracción, y al poder expresivo. Tras caracterizar el núcleo del modelo como un tipo restringido de gramática formal, hemos anticipado el uso de gramáticas generales como el vehículo adecuado para resolver dichas limitaciones.

Actualmente estamos trabajando en el refinamiento y la incorporación del modelo basado en gramáticas formales en *Clavy*. A este respecto, un aspecto crítico es encontrar notaciones visuales para describir los esquemas, de forma que resulten usables para expertos que no poseen necesariamente conocimientos previos en informática. Estamos también trabajando en los mecanismos dirigidos por las gramáticas de edición y visualización de objetos, así como en la implementación eficiente de la organización interna de los repositorios. Como trabajo futuro tenemos previsto formular un lenguaje de transformación entre repositorios basado en *esquemas de traducción* formulados sobre las gramáticas que los organizan, así como aplicar el modelo resultante a los distintos dominios en los que estamos trabajando (literatura, lingüística, medicina, etc.).

AGRADECIMIENTOS

Trabajo financiado por el proyecto PID2021-123048NB-I00.

REFERENCIAS

[1] Buendía, F., Gayoso-Cavada, J, Sierra, J.L. Generation of Standardized E-Learning Content from Digital Medical Collections, Journal of Medical Systems 43(7), 188:1-188:8. 2021.

[2] Buendía, F., Gayoso-Cabada, J., Sierra, J.-L. Generation of reusable learning objects from digital medical collections: An analysis based on the MASMDOA framework. Health Informatics Journal, 27(1), 1-16. 2021.

[3] Fernández-Valmayor Crespo, A., A. Fernández-Pampillón, A., Varadero Software Factory. Guía de Gestión del repositorio de Objetos Digitales OdA. E-Prints Complutense. 2013. Disponible en Web: http://eprints.sim.ucm.es/20263/ [Consulta: 10 de julio de 2023].

[4] Fernández-Pampillón, A., Gayoso-Cavada, J., Sarasa-Cabezuelo, A., Sierra, J.-L. OdA y Clavy: versatilidad para la creación y gestión de colecciones de objetos digitales. Encuentros digitales: escrituras, colecciones, aprendizajes en español, Universidad Complutense, 2019, pp. 177-210. 2019.

[5] IEEE Standard 1484.12.1-2002. 2002. IEEE Standard for Learning Object Metadata

[6] Romero, D., Bueren, J.-L. Networking Women Translators in Spain (1868-1936) and their Presence in the Mnemosyne Digital Library. Electronic Library 36(2), 305-318. 2018.

[7] Goicoechea, M. The Ciberia Project: An Experiment in Digital Hermeneutics. Revista Texto Digital, 11(1), 4-20. 2015.

[8] Márquez, M., Fernández-Pampillón, A., Sánchez, P. A novel Cognitive Model of Digital Didactic Dictionary for Learning Foreign Languages. Application to Latin and German. DEMO. Sixth biennial conference on electronic lexicography, eLex 2019, Sintra, Portugal. 1-3 October 2019.

[9] Gayoso-Cabada, J., Rodríguez-Cerezo, D., Sierra, J._L. Learning object repositories with dynamically reconfigurable metadata schemata. 2016 International Symposium on Computers in Education (SIIE), Salamanca, Spain, 2016.

[10] Gayoso-Cabada, J., Rodríguez, D., Sierra, J.-L. Browsing Digital Collections with Reconfigurable Faceted Thesauri. En "Complexity in Information Systems Development - Proceedings of the 25th International Conference on Information Systems Development". Lecture Notes in Information Systems and Organisation 22, pp. 378-389. Springer. 2017.

[11] Gayoso-Cabada, J., Gómez, M., Sierra, J-.L. A Smart Cache Strategy for Tag-Based Browsing of Digital Collections. En "New Knowledge in Information Systems and Technologies Vol 1". Advances in Intelligent Systems and Computing 93, 546-555. Springer. 2019.

[12] Gayoso-Cabada, J., Gómez, M., Sierra, J.-L. Enhancing the Browsing Cache Management in the Clavy Platform. 2018 International Symposium on Computers in Education (SIIE), Jerez de la Frontera, Spain, 2018.

[13] Hopcroft, J.E., Motwani, R., Ullman, J.D. Introduction to Automata Theory, Languages, and Computation. Addison-Wesley. 2006.

[14] Dubé, D., Feeley, M. Efficiently building a parse tree from a regular expression. Acta Informatica, 37, 121–144. 2000.

[15] Murata, M., Lee, D., Mani M., Kawaguchi, K. Taxonomy of XML schema languages using formal language theory. ACM Transactions of Internet Technoloy, 5(4), 660–704. 2005.

APRENDIZAGEM COLABORATIVA NO ENSINO SUPERIOR: O PAPEL DO *PADLET* NO DESENVOLVIMENTO DE COMPETÊNCIAS DE ESCRITA ACADÉMICA

Collaborative learning in higher education: the role of Padlet in developing academic writing skills

Mariana Oliveira Pinto
Instituto Politécnico de Setúbal, Escola Superior de Educação
CIDTFF, Universidade de Aveiro
mariana.pinto@ese.ips.pt

***Resumo*—Neste texto apresenta-se uma experiência de formação realizada em contexto de ensino superior, numa unidade curricular de escrita académica do plano de estudos de três mestrados em ensino. A experiência centrou-se no desenvolvimento da escrita, a partir do trabalho colaborativo online realizado na ferramenta *Padlet*. Os resultados obtidos apontam para a valorização da utilização do mural no trabalho colaborativo realizado, na comunicação entre pares e com o professor e, ainda, no feedback dado ao longo do processo.**

***Abstract*— This text presents a training experience developed in the context of higher education, in an academic writing course within the curriculum of three teaching master's degrees. The experience focused on the development of writing skills through online collaborative work using the Padlet tool. The results obtained highlight the importance of using the Padlet wall in the collaborative work, in communication among peers and with the professor, as well as in providing feedback throughout the process.**

Palavras-chave—Padlet, trabalho colaborativo, escrita académica, ensino superior

Keywords—Padlet, collaborative work, academic writing, higher education

I. Introdução

Com base no pressuposto de que a escrita é uma ferramenta fundamental para a construção e explicitação do conhecimento e, portanto, um requisito indispensável para o sucesso escolar, diversos estudos evidenciam as dificuldades de escrita dos estudantes que frequentam o ensino superior [1][2][3][4]. Neste sentido, a academia portuguesa tem procurado dar resposta a este problema, integrando no plano de estudo de diversas licenciaturas e mestrados unidades curriculares (UC) destinadas ao ensino da escrita [2].

Foi com base nestes princípios que se desenvolveu uma experiência formativa cujo enfoque se centrou na definição das estratégias propiciadoras da aprendizagem efetiva da escrita em contexto académico, mais concretamente numa UC de escrita académica em Português, do 1.º ano de três mestrados em ensino de uma instituição de ensino superior portuguesa, que envolveu 50 estudantes. Este texto tem como objetivos apresentar o percurso didático desenvolvido para o género relatório de investigação, requisito indispensável para a conclusão do curso, e analisar as potencialidades do trabalho colaborativo online com recurso ao *Padlet* (https://padlet.com).

Todo o processo teve como princípio orientador a aprendizagem ativa em sala de aula, com o foco de ensino centrado no estudante, a partir da definição de metas e planos de trabalho, autoavaliação e estudo independente, tendo sido valorizada a aprendizagem colaborativa. O trabalho pedagógico desenrolou-se em moldes oficinais, gerando dinâmicas cognitivas, processuais e colaborativas de sustentação do processo de escrita e de revisão dos sucessivos produtos. Destaca-se, ainda, na matriz destas práticas, a avaliação centrada no estudante, de natureza formativa e reguladora, tendo sido construída uma linguagem comum entre a docente e estudantes acerca dos requisitos das tarefas e dos critérios que subjazem à sua avaliação, privilegiando-se o *feedback* dado à escrita pela docente e pelos estudantes ao longo de todas os momentos do processo, tendo sido criadas dinâmicas diferenciadas, como a auto e heteroavaliação.

II. O *Padlet* e a aprendizagem colaborativa online da escrita

Em contexto de ensino superior, torna-se fundamental que os estudantes leiam e escrevam textos da esfera académica, cuja especificidade implica um conhecimento aprofundado das suas características e propriedades configuradoras, nomeadamente, (i) localizar e selecionar eficazmente a informação a partir de diferentes fontes; (ii) conhecer as especificidades do discurso académico; (iii) produzir textos usados em contexto académico, respeitando as suas características discursivas e linguísticas e (iv) mobilizar os conhecimentos adquiridos na produção de textos académicos em diferentes unidades curriculares e, futuramente, na vida profissional.

Contrariamente à perspetiva da escrita centrada no produto, que atribui ao professor o papel de mero "espetador-avaliador" das produções dos alunos, os modelos processuais da escrita, sobretudo a partir de Hayes e Flower [5], ao traduzirem a complexidade do processo de escrita, contribuem para a valorização de dinâmicas colaborativas na produção textual que favorecem o pensamento reflexivo, nomeadamente quando os participantes argumentam a favor ou contra determinado ponto de vista ou estrutura linguística, permitem um maior enfoque na organização e estruturação de ideias e favorecem um maior desenvolvimento do conhecimento linguístico e metalinguístico dos estudantes [6]. Neste sentido, o docente não "ensina" ou "expõe" as características do género textual aos estudantes, mas são estes que, colaborativamente, investigam e descobrem as características do género, a partir da leitura de textos de referência [2]. Esta forma de aprendizagem estimula não apenas a apropriação dos conteúdos através da cooperação e partilha, como também a responsabilidade e a corresponsabilização de cada estudante pelos resultados de aprendizagem do grupo.

Antes da utilização de tecnologias na educação, as práticas de escrita colaborativa desenvolvidas em sala de aula dependiam quase exclusivamente de versões escritas pelos estudantes e corrigidas em papel pelos colegas e/ou professores, dificultando as dinâmicas de partilha e os comentários simultâneos [7]. Com a massificação das ferramentas digitais, passaram a estar disponíveis um conjunto de recursos que tornaram possível a troca de ideias em todas as fases do processo de escrita, emergindo outras lógicas de gestão do tempo, de edição, de papéis atribuídos durante todo o processo de escrita, que se aproximam mais das lógicas dos textos digitais contemporâneos [8].

É neste contexto que a utilização de um *Padlet* pode constituir uma ferramenta importante no apoio a este processo, possibilitando o acompanhamento da evolução do trabalho realizado pelos estudantes, nomeadamente a identificação das dificuldades com que se vão deparando, e a disponibilização de materiais de apoio importantes para ultrapassar essas dificuldades. Enquanto ferramenta digital, o *Padlet* é uma plataforma online (https://padlet.com) na qual podem ser criados murais virtuais para registar, guardar e partilhar conteúdos (imagens, vídeos, documentos de texto, blogs e/ou portefólios, entre outros), com diferentes *designs* e diferentes disposição dos conteúdos e privacidade, podendo ser exclusivos (fornecendo aos visitantes o código QR, as ligações e/ou palavras-passe para os murais) ou torná-los públicos, encontrados através de pesquisas online [9], [10].

Pelas suas características, torna possível novas abordagens na construção e partilha de informações e de conhecimentos, permitindo um trabalho colaborativo durante o processo de elaboração dos murais, assumindo o professor o papel de facilitador do processo de ensino e de aprendizagem [11] e os alunos o de protagonistas desse processo [12]. Enquanto ferramenta, o *Padlet* assume igual importância no processo de avaliação das aprendizagens, quer enquanto produto, pela forma como torna visível todos os resultados dos alunos, quer enquanto processo, através do *feedback* que coloca em interação professores e alunos ao longo de todas as tarefas.

III. APRESENTAÇÃO DA EXPERIÊNCIA DE FORMAÇÃO

O projeto, que teve como objetivo desenvolver competências de escrita académica a partir do trabalho colaborativo com recurso ao *Padlet*, envolveu 50 estudantes de três mestrados em ensino de uma instituição de ensino superior portuguesa e foi desenvolvido ao longo de um semestre letivo.

Numa fase inicial foi criado um mural partilhado (Fig. 1), que foi sendo preenchido colaborativamente ao longo do processo de escrita.

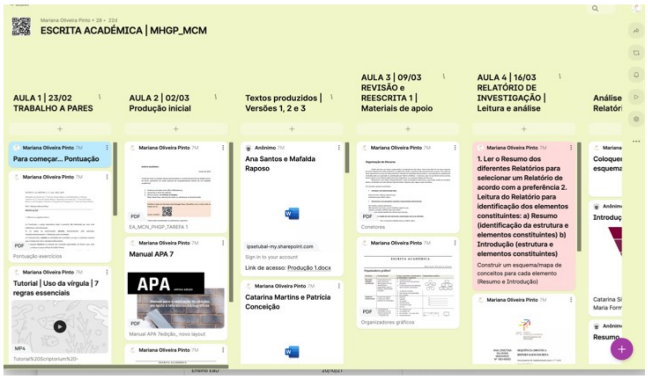


Fig. 1. *Padlet* colaborativo – excerto do mural.

No mural foram colocados de forma faseada, quer os documentos de apoio à escrita e os modelos de relatórios de investigação para leitura e análise, quer as diferentes versões dos textos produzidos e comentados pelos estudantes e pela docente: 3 versões no módulo (M)1, 3 versões no M3 e 2 versões nos M5 e 6.

Na Fig. 2 estão esquematizados os diferentes módulos e as tarefas desenvolvidas em cada um.

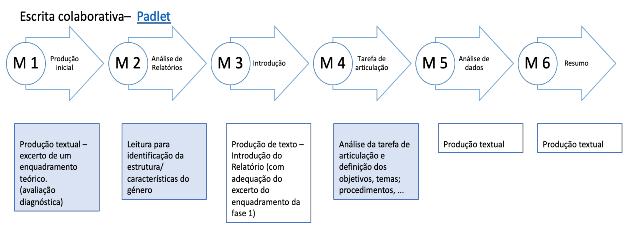


Fig. 2. Módulos do trabalho colaborativo

Apresentado o contexto e os objetivos da produção textual, os estudantes produzem um primeiro texto a pares com base nas suas representações do género textual (M1). Este módulo permitiu ao professor identificar as dificuldades apresentadas, planificar os módulos de trabalho em função dessas dificuldades e disponibilizar no *Padlet* os materiais de apoio e respetivas tarefas.

O M2 centrou-se na leitura e análise de exemplares do género Relatório de investigação e os estudantes criaram infográficos de sistematização da estrutura, com apoio do *Canva* (Fig. 3), posteriormente partilhados no *Padlet* e comentados pela docente e pelos pares.

Fig. 3. Exemplo de infográfico construido por estudantes

Esta forma de agir permitiu igualmente um ensino diferenciado, uma vez que foram identificados diferentes níveis de dificuldade em diferentes estudantes, fazendo com que os materiais de apoio disponibilizados tivessem em conta essa diversidade. Por outro lado, a partir da construção colaborativa de grelhas de auto e heteroavaliação nos diferentes módulos, foi possível a monitorização das aprendizagens, a partir de produções textuais intermédias e não apenas na tarefa de produção final.

Ao longo dos diferentes módulos, os estudantes foram convidados a aceder às produções dos diferentes pares e colocar comentários nos textos. Semanalmente, a docente analisava as produções e os comentários colocados e apresentava sugestões de melhoria e respostas a questões/comentários deixados pelos estudantes. Com base nos diferentes comentários, os estudantes reescreviam os textos para novo ciclo de comentários até à produção final, que correspondeu ao texto final sujeito a avaliação quantitativa no final do semestre. Na Fig. 4 apresenta-se um excerto de uma produção comentada pelos estudantes e pela docente.

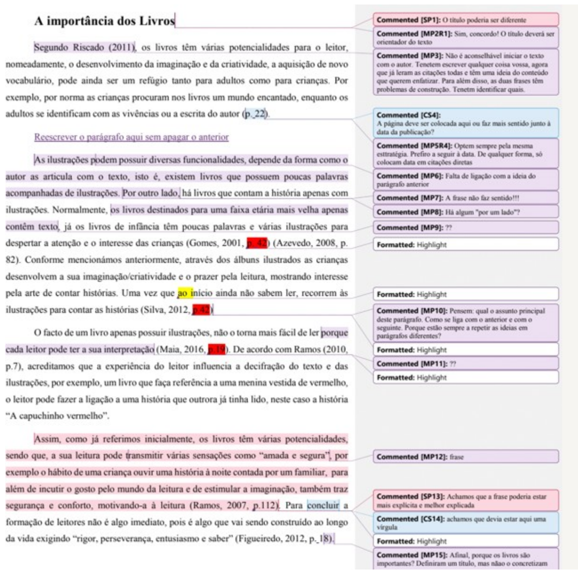


Fig. 4. Exemplo de texto partilhado no Módulo 1 (M1), comentado colaborativamente.

Para além da partilha de documentos, o *Padlet* foi igualmente utilizado para colocar comentários de natureza diversa. Uma vez que os estudantes recebiam no email as notificações de alteração propostas pelo docente, foram várias vezes alertados para os prazos de realização das tarefas individuais ou a pares, acederam a comentários das tarefas de estudo autónomo realizadas e foram avisados da introdução de novos materiais de apoio ou tarefas a realizar.

IV. Apresentação e Análise dos Resultados

Ao longo da experiência formativa, os estudantes avaliaram, individualmente, num questionário disponibilizado online, os diferentes módulos do processo de escrita, nomeadamente o trabalho realizado, a autoavaliação da participação no trabalho a pares, áreas em que melhorou, áreas em que ainda sente dificuldades e reflexão sobre o percurso de escrita colaborativa desenvolvido em cada módulo.

Na fase final do projeto, o questionário centrou-se nas perceções dos estudantes relativamente às potencialidades do *Padlet* no processo de ensino e de aprendizagem: (i) na organização da informação; (ii) na interação e comunicação estabelecidas e (iii) no feedback realizado.

Neste texto, e pela especificidade que tal análise implica, não serão apresentados os dados relativos às aprendizagens dos estudantes no que diz respeito às diferentes dimensões da escrita, nomeadamente as características dos textos produzidos no início e no final do processo.

Quanto à dimensão do trabalho colaborativo, foram propostas 3 questões de resposta aberta e foram criadas categorias de análise a partir das respostas dadas.

Relativamente à primeira questão- *aspetos que considera mais relevantes no trabalho colaborativo realizado*, as respostas obtidas foram analisadas e organizadas em seis categorias de análise. Na Fig. 5 apresentam-se as categorias criadas e as respostas obtidas na questão.

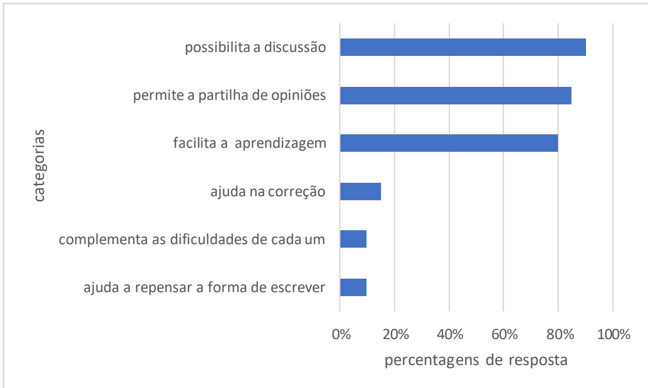


Fig. 5. Trabalho colaborativo – percentagens de respostas por categoria.

Os aspetos mais relevantes dizem respeito quer aos momentos de discussão e partilha que o trabalho colaborativo possibilitou, quer à dimensão das aprendizagens realizadas, uma vez que consideram que o facto de escreverem colaborativamente facilitou a compreensão de alguns temas e/ou conteúdos mais *complicados* da produção textual. Outras categorias (*complementa as dificuldades de cada um* e *ajuda a repensar a forma de escrever*) são de natureza residual e circunscritas a um número de estudantes muito diminuto.

Em alguns comentários colocados, os estudantes consideraram ter sido uma experiência que, inicialmente, lhes provocou alguma apreensão, pela dificuldade que diziam sentir em *pensar e escrever acompanhadas*. No entanto, e após a primeira produção, reconheceram ter sido *uma experiência motivadora e enriquecedora*.

No que diz respeito à segunda questão- *potencialidades do Padlet na organização da informação disponibilizada*, as respostas dos estudantes estão identificadas na Fig. 6.

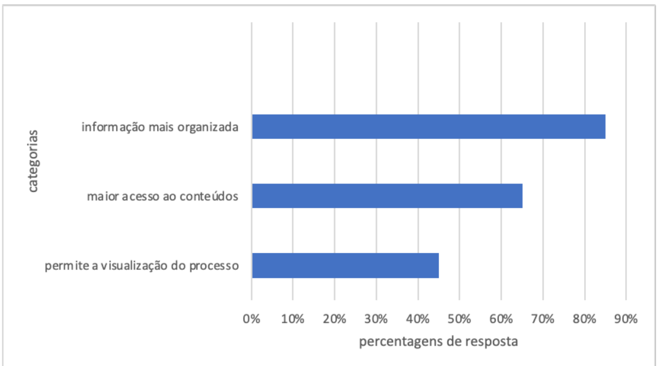


Fig. 6. Potencialdades da ferramenta *Padlet* na organização da informação – percentagens de respostas por categorias.

O papel do *Padlet* na organização da informação é o aspeto mais relevante das respostas obtidas. A título de exemplo, um estudante refere que *os materiais encontram-se organizados pelas temáticas, facilitando a sua utilização.*

De facto, pelas suas características, o mural permite a organização dos temas/conteúdos de forma linear e facilmente identificáveis. Essa é também a ideia que emerge da categoria *permite a visualização do processo* que, de acordo com alguns comentários feitos pelos estudantes, *é uma vantagem relativamente ao Moodle ou aos portefólios digitais*, por exemplo.

Quanto à questão *potencialidades da ferramenta Padlet na comunicação*, as respostas obtidas foram organizadas nas categorias e com as percentagens de resposta identificadas na Fig. 7.

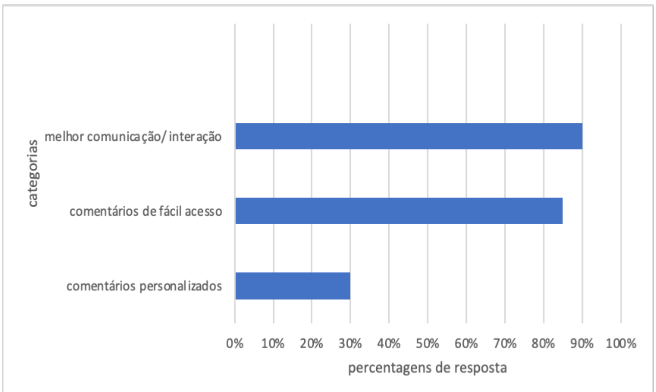


Fig. 7. *Potencialdades da ferramenta Padlet na interação* – percentagens de respostas por categorias.

Relativamente à interação aluno-professor e aluno-aluno, os estudantes consideram que o mural facilita o processo de comunicação entre os pares e entre a professora e estudantes, quer pelo facto de essa interação ser quase imediata, quer pela facilidade com que acedem aos comentários. A título de exemplo, um estudante refere: *é super fácil haver interação entre docente/estudante, seja através de comentários e de espaços para comunicar.* O facto de os comentários serem personalizados é também um aspeto valorizado.

A última questão relaciona-se com o *feedback* ao longo do processo de construção textual. Neste ponto não se apresentam os dados relativos à sua qualidade ou importância no processo de construção, revisão e aperfeiçoamento textual, mas apenas no papel do *Padlet* no acesso aos comentários e apreciações feitos, quer pela professora, quer pelos pares.

De acordo com as respostas dos estudantes, as categorias consideradas mais relevantes, assim como as percentagens obtidas estão identificados na Fig. 7.

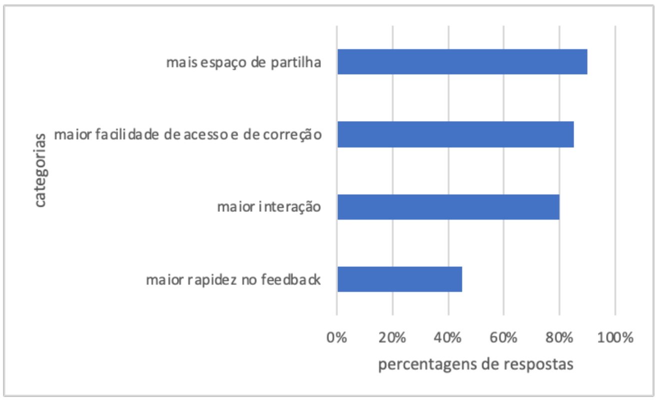


Fig. 8. *Potencialdades da ferramenta Padlet no acesso ao feedback* – percentagens de respostas por categorias.

Os estudantes consideram que o *Padlet* possibilita um maior espaço de partilha e uma maior facilidade de acesso e de correção das diferentes versões dos textos. Para além disso, pelas características do mural que permite a partilha de comentários em tempo real, há uma maior interação e mais rapidez no feedback: é *super fácil receber um feedback da docente e quanto mais rápido se recebe o feedback melhor, com o padlet essa rapidez é fácil,* ou ainda, *o Feedback é maior e mais rápido, funciona com um chat direto.*

V. Considerações finais

Face à necessidade de se desenvolverem estratégias propiciadoras da aprendizagem efetiva da escrita em contexto de ensino superior, mais concretamente numa UC de escrita académica em português do 1.º ano de três cursos de mestrado em ensino de uma instituição de ensino superior, foi desenvolvida uma experiência de formação que utilizou o *Padlet* como ferramenta privilegiada no apoio às tarefas de escrita colaborativa online.

Foi definido um plano de trabalho para o semestre, organizado em 6 módulos de trabalho, valorizando-se o papel do *feedback* ao longo de todo o processo, o estudo independente e aprendizagem colaborativa, assumindo o professor o papel de facilitador do processo.

Nesta comunicação privilegiou-se a análise do papel do *Padlet* no processo de aprendizagem colaborativa, embora tenha sido também possível identificar o desenvolvimento de competências de escrita, nomeadamente, aspetos macro (de estrutura) e micro textual (de natureza linguística). Num outro estudo realizado com 54 estudantes de 17 anos sobre o papel do *Padlet* no desenvolvimento de competências de escrita [10], o autor corrobora a importância desta plataforma no desenvolvimento de competências de escrita, quando conclui que existe uma diferença significativa na capacidade de redação de textos entre os alunos que utilizaram o mural e aqueles que trabalharam nos modelos tradicionais de escrita manual ou num processador de texto.

Relativamente aos dados recolhidos, é possível concluir que o mural possibilitou de forma mais efetiva a interação entre estudantes e docente e permitiu o acesso mais rápido ao *feedback* ao longo do processo. Para além destes aspetos, a organização e a visualização dos materiais foi igualmente um aspeto valorizado. De facto, a configuração da ferramenta permite a apresentação organizada e sequencial dos materiais, que podem ser organizados numa linha temporal e/ou temático. Esta mesma ideia decorre de outros estudos realizados, nos quais também se conclui tratar-se de um recurso "interessante, versátil', colaborativo e dinâmico" [13]

Na perspetiva da docente, a estratégia definida possibilitou o acompanhamento da evolução do trabalho realizado e a identificação das dificuldades ao longo do processo. Este aspeto permitiu um acompanhamento mais individualizado dos pares e uma maior focalização nas suas necessidades de apoio.

Numa perspetiva de análise dos constrangimentos sentidos, para além dos limites de gratuitidade da ferramenta (limitada a 3 murais), o que não permite guardar todos os *Padlet* criados. Para além disso, não permite tornar privados *posts* específicos no mesmo mural, o que, no caso, dificultou a interação individual em momentos mais específicos, havendo a necessidade de recorrer ao email.

VI. Referências

[1] A. P. Cabral, "Leitura, compreensão e escrita no Ensino Superior e sucesso académico," [Tese de doutoramento, Universidade de Aveiro. Aveiro, 2003].

[2] A. Cardoso, and M. Pinto, "Contributos para uma didática da escrita académica no ensino superior: Um percurso centrado no artigo científico," F. Caels, L. F. Barbeiro, and J. V. Santos, Eds. Discurso Académico: Uma área disciplinar em construção, CELGA-ILTEC: Universidade de Coimbra, ESECS, Politécnico de Leiria, 2019, pp. 153-181.

[3] J. Carvalho, and J. Pimenta, "Escrever para aprender, escrever para exprimir o aprendido" [VIII Congresso Galaico Português de Psicopedagodia. Braga, 2019].

[4] L. C. S. Rodrigues, "Dificuldades de Síntese na Escrita de Alunos do Ensino Superior Politécnico". [Tese de Doutoramento, Universidade de Aveiro, 2009].

[5] J. Hayes, and L. Flower, "Identifying the organization of writing processes," in W. Gregg & E. Steinberg, Eds, Cognitive processes, in writing. Lawrence Eribaum Associates Publishers, 1980, pp. 3-30, 1980.

[6] A. Bustos, "Escritura colaborativa en línea. Un estudio preliminar orientado al análisis del proceso de co-autoría," in RIED: revista iberoamericana de educación a distancia, Vol 12, pp. 33–55, 2009.

[7] S. G. Dantas, "A Escrita Colaborativa no Google Docs: Uma intervenção pedagógica no ensino da língua inglesa," [Dissertação de mestrado, Instituto Federal de Educação, Ciência e Tecnologia do Rio Grande do Norte, Universidade Estadual do Rio Grande do Norte, Universidade Federal Rural do Semi-Árido, 2020].

[8] K. López, K. S. Gil, and C. E. Pedraza Ramírez (2016). Característiques de l'escriptura collaborativa en línia de textos multimodals en un curs virtual. BiD: textos universitaris de biblioteconomia i documentació, 37.

[9] D. Ann, and Z. Zainor, "Padlet as an educational tool: pedagogical considerations and lessons learnt", [10th International Conference on Education Technology and Computers, dec. 2018]. DOI: 10.1145/3290511.3290512.

[10] T. Ilham, "The efectiveness of using padlet in teaching writing descriptive text", in Journal of Applied Linguistics and Literacy", Vol 2, N.º 2, september 2018, pp. 71-88. https://jurnal.unigal.ac.id/index.php/jall/index

[11] M. Mota, T. Machado, and P. S. Crispim, "Padlet no contexto educacional: uma experiência de formação tecnológica de professores," in Redin-Revista Educacional Interdisciplinar, Vol 6, 2017.

[12] H. Santos, and F. D'Andrea, F., "Etodologia ativa e ferramentas digitais: facilitadores de uma aprendizagem significativa," [V CONEDU Congresso Nacional de Educação, 2018].

[13] R. Lidianne, and Costa, C., "O uso do padlet como recurso digital de avaliação de aprendizagem em tempos de pandemia: uma breve reflexão", in RE@D – Revista de Educação a Distância e Elearning, Vol 4, N.º 2, novembro 2019, pp. 77-96.

NEUROEDUCATION: GUIDELINES FOR COMPUTATIONAL THINKING TRAINING

1st Cristiana Araújo
ALGORITMI Research Centre/LASI, University of Minho
Braga, Portugal
decristianaaraujo@hotmail.com

2nd Pedro Rangel Henriques
ALGORITMI Research Centre/LASI, University of Minho
Braga, Portugal
prh@di.uminho.pt

3rd João José Cerqueira
Life and Health Sciences Research Institute (ICVS), University of Minho
Braga, Portugal
jcerqueira@med.uminho.pt

***Abstract*—Computational Thinking (CT) skills are a key competency for all citizens, but for Computer Programming students these abilities are crucial. Several studies claim that students have deficits in many of the CT skills and therefore it is important to develop and improve these skills. For that purpose, Teachers responsible for the children's education have to plan as soon as possible effective ways for training CT skills. There are already many Learning Resources (LR) for this training, however, we believe that Neuroeducation can contribute to improving the impact of these LR in the teaching and learning process. Currently, Educational Neuroscience presents a solid set of scientific evidence on how the brain learns more effectively. This important knowledge about the brain's learning process can be turned into principles applicable in Education. This paper starts emphasising those principles that can benefit the teaching and learning process. Based on this scientific evidence, we propose the adoption of a set of guidelines that can contribute to innovative CT training. Neuroeducation applies the latest theoretical advances in the human brain and psychology to pedagogy. The guidelines inspired by Neuroeducation that we propose here aim to provide instructions for the teacher to apply in their pedagogical practices and in LR, in order to promote more effective training. One concrete LR for primary school, created by our Master's Students in Computing Education, will be used, as a case study, to illustrate our proposal.**

***Index Terms*—Computational Thinking, Neuroeducation, Pedagogy, Learning Resources**

I. INTRODUCTION

We are in a world in constant evolution! The present and future generations increasingly need to have strong problem-solving skills in order to be prepared to overcome the challenges they will encounter in their daily lives, at school, and in the world of work.

Computational Thinking (CT) training can help acquire and improve these problem-solving skills [1]. CT is a problem-solving approach that requires (but is not limited to) the following skills: logical reasoning (predict and analyze; explain why something happens) [2], [3]; abstraction (identifying what is important and remove unnecessary details) [2], [3]; decomposition (breaking a problem into smaller parts that are easier to understand and solve) [2], [3]; algorithmic thinking (ordering a set of instructions or rules for doing something) [2], [3]; patterns recognition (identifying similarities between problems and solving the problem using solutions previously defined in other problems and based on experiences) [2], [3]; and evalua- tion (ensure that the solution is adequate to solve the problem, checking the limit cases) [2], [3]. These skills are enhanced by the following abilities or attitudes: tinkering (change and see what happens – cause and effect experiments) [3]; creating (design and make with creativity) [3]; collaborating (working as a team) [2], [3], debugging (finding and fixing errors) [3]; and persevering (continue and never give up, even when the problem is more complex to solve) [2], [3]. We believe that if these skills are trained from an early age, children will benefit for their learning process in various subjects. Furthermore, when these students arrive at the Computer Programming Courses, they will find it easier to learn to program and solve problems using the computer.

The acquisition of any competence requires training. Train- ing can be carried out freely, for example through a game chosen by the student, or it can be conducted by the teacher. During training, we recognize that the teacher plays an im- portant role both in choosing the most appropriate Learning Resources (LR) for training and in guiding the student in his learning process. However, it is important to understand whether training is effective and how we can make it more effi- cient. We believe that connecting Neuroeducation and teaching practice through studying the latest theoretical achievements in Neuroscience and Psychology can help to achieve more effective CT training.

For this, we discuss scientific outcomes that can improve the teaching and learning process. Based on the knowledge generated by Neuroeducation, we propose the adoption of a set of guidelines that can contribute to a more efficient CT training. The principles of Neuroeducation that form the basis of our proposal are intended to aid teachers in their classes, in order to reinforce and innovate their pedagogical methods and contribute to an effective learning process. The aim of our research is to provide the teacher with a set of guidelines and hints to more effectively use LR to train CT skills in the classroom. It is important to mention that the proposed guidelines can be applied to any subject to be taught and at different school levels. Nevertheless, to better illustrate our proposal, we are going to present an example LR that was built to be used in primary school classes.

This paper is organized in four sections. In Section II, our proposal is discussed introducing Neuroeducation inspired guidelines for improving CT training. Section III presents a case study, with a concrete LR that trains some CT skills in order to demonstrate our proposed guidelines. Finally, Section IV presents the conclusions and future work.

II. Neuroeducation inspired Guidelines to improve the training of Computational Thinking

Neuroeducation is a new transversal discipline that inte- grates Neuroscience, Psychology and education theories to decipher cognitive and emotional processes that lead to better teaching methods and curricula [4]. In recent years, Neuroed- ucation initiatives have grown a lot, using research outcomes about learning, attention, memory, language and other areas of cognitive neuroscience to inform educators about the best teaching and learning strategies. Neuroeducation proposes a new stage in the development of pedagogy: teachers need to know about how their students learn and acquire the skills being taught. It is fundamentally different from traditional pedagogy in terms of its philosophical foundation, research methods and nature of the subject [4].

Learning is achieved through the reorganization of synapses, circuits and networks of neurons [5], which are interconnected and distributed throughout the brain. This reorganization in- volves and promotes the development of mental functions, such as: motivation, emotion, attention, memory, language and mathematical/logical reasoning. The pedagogical strategies used by educators in the teaching and learning processes are prompts that stimulate the improvement of these mental functions and lead to the reorganization of the nervous system, allowing the learning of new knowledge, skills and attitudes. However if the teacher had a manual on how the brain learns and how to leverage the student's learning process, he could implement a more personalized and effective pedagogy.

The literature on Neuroeducation and Computer Program- ming includes some works that resort to the Cognitive Load Theory to improve programming learning [6]–[8]. However, in the specific area of Computational Thinking (CT) and Neuroeducation, we did not find any published investigation. In this perspective, and with the aim of creating an approach to train CT more effectively, we carried out a literature review in the field of Neuroeducation. From that study we identified several scientific evidences. In view of these, we have adopted 10 guides that teachers can apply in their pedagogical practice in order to enhance CT training.

1) Repetitive Learning enhances knowledge acquisition.

Lasting learning is dependent on the formation and stabiliza- tion of new synaptic connections, which requires repetition and time for elaboration, recall and consolidation to be stored in long-term memory [9], [10]. Investigation showed that study- ing one subject superficially, quickly moving on to another and only returning to that subject at the time of the exams, does not allow for the necessary neural processing for effective learning. On the other hand, if the learner repeats the study on the subject for several days in a different way, new synapses will be consolidated and built, and consequently the stored information will resist longer [11], [12].

2) Increasing Cognitive Load benefits learning..

According to Sweller [13], Cognitive Load Theory (CLT) is an instructional approach based on knowledge of human cognitive architecture, including the limitations of working memory, how information is organized in long-term memory (LTM), and how the two memory structures are correlated. The CTL contains the following strategies: managing intrinsic load; decreasing extraneous load; and germane load optimization. Studies show that the challenges proposed to students must be presented with an increasing level of complexity. The difficulty of the challenges must be in line with the student's progress. This allows the student to feel that he has the capacity to solve the problem and increases his motivation. If the challenge is perceived of much more complex than what the student is capable of solving, he will become discouraged and he will give up [14], [15].

3) Spaced Training increases long-term retention.

New mental representations are consolidated as long-term memory via neuroplasticity phenomena, leading to reorganiza- tion and strengthening of connections between neurons [16]. Therefore, learning takes time [17], [18]. The student has to codify the information, actively repeat it in different situations and elaborate it through different cognitive processes. That is, the Learner needs time and encouragement from the teacher to think, interconnect information and make sense of what he is learning. Studies reveal that practice and repetition spaced over a period of time facilitate the consolidation of information in long-term memory [19], [20]. However, brain changes that promote learning also require periods of sleep [21], [22]. It is during sleep that the brain reviews the experiences lived and the information received during the day, and makes the important ones more stable and definitive. It is important to re- inforce students' and parents' understanding of the importance of sleep for learning [11], [23].

4)The integration of new information with prior knowl- edge benefits the learning process.

Elaboration corresponds to the association of new information with knowledge already existing in the brain [24]–[26]. The brain areas that process memory and prior knowledge are activated in a situation in which a new stimulus, related to prior knowledge, is presented [27]–[29]. Meaningful learning occurs when the student connects this new information to prior knowledge [30]. The more associations the learner establishes with the information he already has stored [31], [32], the easier he will make use of it in the future, as he will integrate what he has just learned, in the broader context of what he already knows about the world [33]. The connections that the student makes favor the storage and retrieval of new information, contributing to the constitution of meaning in relation to what they are learning.

5) Concept Maps help with knowledge integration.

The elaboration of concept maps favors learning, as it allows the student to summarize or unravel concepts, analyze complex problems and identify solutions [34], [35]. The elaboration of concept maps allows the student to make his thinking visible, which is an excellent metacognition strategy. Metacognition is the process of becoming aware and monitoring the stages of thinking [36]. From the perspective of Neuroscience, self-regulation and metacognition [37] are integrated because, in the brain, these processes are intrinsically interrelated [38]. Asking the student to record or communicate what he thinks favors his understanding and strengthens learning. When stu- dents speak, write or draw their ideas, they are deepening their cognition [39].

6) The student's ability to choose favors learning.

According to Lin-Siegle and others [40], when students have a say in what and how they learn, they are more motivated to engage with new learning. The possibility of choice, on the part of the student, plays an important role in promoting intrinsic motivation [41], as it allows intertwining student interests with the school curriculum. The process of making choices generates feelings of interest and satisfaction in the student that encourage voluntary involvement in the activity or environment. The teacher, by promoting choice, makes room for the student to take responsibility for his own learning, commit to self-directed activities and find value for his own learning, awakening his intrinsic motivation for what is pro- cessed in the classroom (Student Agency) [42], [43].

7) Icebreaker activities enhances students' attention.

Studies claim that in order to carry out a task, the learner needs to be in a greater state of mind and for that it is important to think of something more dynamic or something that arouses curiosity to start the class. Starting the class with something new, something unexpected, such as a game, a puzzle or an im- age, which arouses the desire to learn the topic to be addressed, is more likely to wake up the learner's attention [44]. A good question can open the mind at the beginning of the class and draw attention to the topic. Curiosity awakens motivation. Evidence from Neuroscience points out that sharpening the learner's curiosity and developing his ability to formulate questions should be an educational objective [45].

8) Cognitive Closure enhances learning and memory consolidation.

Cognitive Closure is the activity devoted, at the end of each learning moment, to summarize and clarify the own mind's perception of what has been learned. This activity is crucial as it provides an opportunity for the student to attach sense and meaning to the new learning (both requirements are important for retention) [43]. Cognitive Closure promotes the recall of information [46], that is, the retrieval of information from memory, which activates the neural circuits related to that mental representation [47]. Each time the student recalls the stored information, a new elaboration takes place, further consolidating this information in the memory [32], [47].

9)Using various Sensory Channels, reinforces the mem- orization process.

As mentioned earlier, lasting learning requires repetition and time stored in long-term memory [48]. Research using be- havioral and brain activity measures state that the diversity of stimuli [48], [49] contributes to improving memory for- mation and learning performance [50], [51]. This reinforces the premise of the importance of diversified repetition [50], [51], for the elaboration and consolidation of information in memory [52]. Scientific evidence argues that it is crucial to use the various sensory channels for accessing the brain and processing information, such as vision, smell, shape, taste, among others [11], [53], [54]. According to these studies, making mistakes and looking for new paths, listening and writing, watching videos, explaining to colleagues, making mental maps, clearing doubts, all favor the creation and strengthening of synapses and give the opportunity for the neural circuits involved with the different sensory modalities to be activated more frequently, forming a more robust memory network and one that is more easily elicited [55].

10) Collaborative work encourages students' involve- ment and autonomy in their learning.

The social brain is a powerful learning mechanism. Meltzoff et al. [56] indicates that social interaction stimulates learning. Classroom contexts that aim at social relationships promote: the perception of self-efficacy [57], motivation [58], [59], critical thinking, and the ability to solve problems [60], as well as, creativity [61]. A study by Clark et al. [62] showed that when students are offered opportunities to actively and equitably participate in collaborative learning activities, they experience feelings of satisfaction and well-being. Teaching methodologies that promote and value social interaction can significantly increase academic performance [63]. They are more pedagogically effective than passive activities or isolated study.

The guidelines presented aim to help teachers in their pedagogical practices. They give hints on how to make training more effective and compatible with how the brain works and acquires knowledge. These guides are similar to a gym training plan. For example, we know that in the gym, to train biceps we have to use different machines (suitable for biceps training), and repeat the exercises on each of them several times a day and for several months. In the same way, these guides inform how LRs (suitable for CT training) should be used to allow efficient training. In the next section, we will illustrate how a teacher can apply these guidelines considering their application to a concrete LR.

III. CASE STUDY: APPLYING NEUROEDUCATION INSPIRED GUIDELINES IN LR

As previously mentioned, the objective of this work is to de- vise pedagogical approaches, duly supported on Neuroscience and Psychology, to improve the training of Computational Thinking (CT) in primary school students, using adequate Learning Resources (LR). For this, we propose the adoption of the guidelines, described in Section II.

In this section we will give an example of how the teacher can apply the guidelines we propose. Remember that the function of the guides is to be hints to apply in the class- room while using a given LR, in order to promote a more effective and lasting training. The LR that we are going to analyze, in light of the guidelines presented, was designed by Eliana Rodrigues—a student of the Master's in Computing Education—to be used in the primary school. It should be noted that the LR author designed the resource without being aware of the guides presented in this paper.

The LR Eliana built is called *Secret Syllables* and aims to train some of the CT skills (namely decomposition, pat- tern recognition, and logical reasoning) without resorting to programming or computing concepts. It was thought to be applied in the 2nd or 3rd year of the Portuguese curriculum (primary school), that is, for students aged 7-9 years old. *Secret Syllables* promotes the development of the ability to compose syllables for building words with two or three syllables. This LR consists of a board (see Figure 1) with the challenges and 5 cards to write the answers to the 5 questions (see Figure 2).

Fig. 1: Board – Secret Syllables

The board in Figure 1 exhibits a table (with lines identified by numbers, and columns identified by letters) with the syllables to be used in the play, a narrative to motivate the game (yellow cloud in the bottom), and 5 different challenges related to animal and fruit names (top left corner). Challenges can be of two types. One type refer directly the syllables; the second type refer a code that is the line and column of the syllable.

In the first challenge (desafio), a story with coded words (eg: 4F-5A-5A; 5B-2D-3B) is presented and the student has to decode them using the table. After decoding the student has to write the word on the card selecting the category it belongs to – fruit (eg: BANANA) or animal (eg: MACACO). The second challenge aims to search the table for the names of two animals (three-syllable) that start with the same code (in the first syllable), for example CA-VA-LO (2D-1E-6C) and CA-ME-LO (2D-3D-6C). In the third challenge, the goal is to identify the code of the following two-syllable words: GALO (5G-6C); GATO (5G-4C); LULA (2C-6E); and MULA

(4D-6E). The fourth challenge aims to build, based on the table, 3 two-syllable words (eg: MA-Ç Ã; SA-PO; VA-CA)

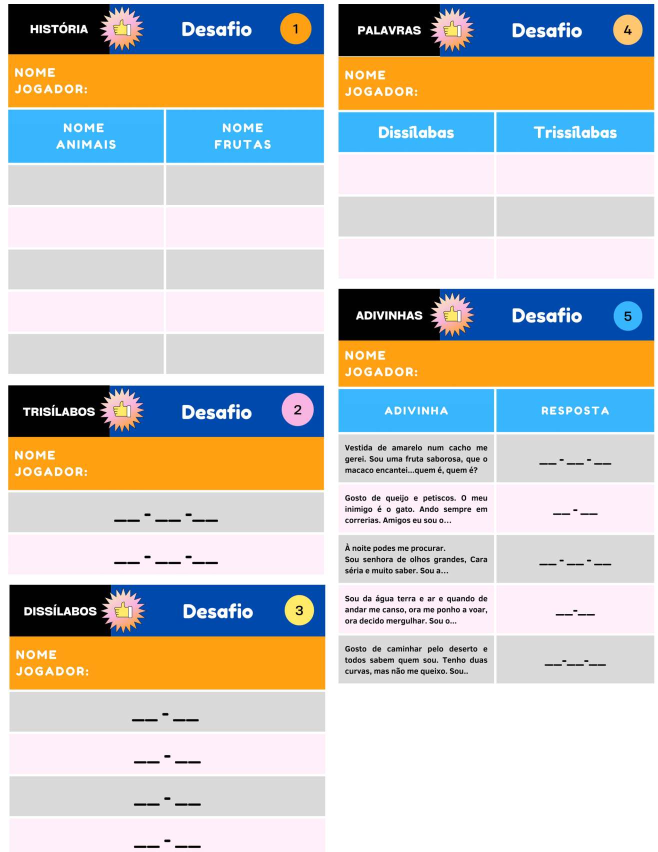


Fig. 2: Cards to write the answers to the proposed challenges on the board

and 3 three-syllable words (eg: JA-VA-LI; CE-RE-JA; GO-RI-LA). Finally, the fifth challenge presents 5 riddles, and the objective is to decipher each riddle and write, based on the table, the code of the answer. The first riddle is: "Dressed in yellow in a curl, I generated myself. I am a tasty fruit that the monkey enchanted... Who am I?" The answer to the riddle is "BANANA" and its code is "4F-5A-5A".

As mentioned above, this LR trains the following CT skills: **Decomposition** – The student has to break the word into parts to form the syllables (challenge 3, 4 and 5); **Pattern Recognition** – Student identifies similarities in the codes that identify the syllables of the word, for example, different words have the same syllables (5B-2D-3B -> MACACO and 5B- 3F -> M A Ç Ã challenge 1 and 2). Furthermore, the Learner will associate the [*space,* – *, space*] pattern to two-syllable words and the [*space,* – *, space,* – *, space*] pattern to three- syllable words (challenges 2, 3 and 5). In particular, challenge 5 also requires logical reasoning to find out the answer to the proposed puzzle.; **Logical Reasoning** – The student perceives the pattern: whenever the word is divided into two parts it is classified as two-syllable, when it is divided into 3 parts it is classified as three-syllable (challenges 4 and 5).

This resource was successfully applied in a Portuguese class with 2nd and 3rd year students. It was found that the 3rd year students were able to respond to all challenges, while the 2nd year students needed more time to respond to some challenges and felt challenge 4 difficult.

To illustrate the application of the guidelines in a real case study, we will show how these instructions/guidelines can help, with tips and suggestions of pedagogical practices, teacher that is using the LR introduced above. Our idea is to simultane- ously provide the medicine (the LR) and its instructions for use (these guidelines). In this way, the teacher obtains an LR enriched with a method of how to effectively train, promoting student involvement and longer-lasting learning.

1. Repetitive Learning enhances knowledge acquisition.

This guideline is already embedded in *Secret Syllables*, as it consists of 5 different challenges to develop the ability to identify and build two and three syllable words.

2. Increasing Cognitive Load benefits learning.

Secret Syllables is in harmony with the guideline, as the level of complexity is increasing throughout each challenge. The first challenge is just to decipher a code to get a word, while in the last challenge the student has to decipher the riddle to know the word and finally has to write the code corresponding to the word.

3. Spaced Training increases long-term retention.

Secret Syllables allows the application of this suggestion: for example, the teacher can apply one challenge per day instead of doing all challenges in the same day.

4. The integration of new information with prior knowledge benefits the learning process.

This LR paves the way to connect new concepts, (two- and three-syllables), with previous knowledge, (classification of a word according too the number of syllables and mono-syllable concept) and this can be highlighted by the teacher during the session. Moreover, the teacher can introduce another term that will be explored in the next year, poly-syllable.

5. Concept Maps help with knowledge integration.

Secret Syllables does not comply to this guideline. We suggest that at the end of the challenges, the teacher asks the students to build a concept map to organize or group all the words they found, throughout the challenges, by the number of syllables (two or three syllables). The teacher can also build a concept map to organize the words they find by fruit, animal and another category.

6. The student's ability to choose favors learning.

Secret Syllables does not conform to the guideline. There are no practical suggestions in this guideline for *Secret Syllables* because this LR does not allow for choice, since the objective is to solve all the challenges.

7. Icebreaker activities enhances students' attention.

Secret Syllables does not satisfy with this guideline. However it is easy to see that the teacher can start the lesson with a puzzle related with the topic under study. For instance, it is enough to collect a set of pictures with different vegetables. Each picture must be cut according to the number of syllables in the name of the vegetable. To play that game in classroom, the teacher must place the mixed images on a table. Each student must assemble the puzzle pieces and paste the picture on a sheet of paper. After building a vegetable image, the student shall write on the sheet the respective name.

8. Cognitive Closure enhances learning and memory consolidation.

Secret Syllables does not propose any activity according to the guideline. However, the teacher can ask the students to say something they learned to the colleague next to them (or two), and then each pair/trio shares this with the whole class. A more elaborate suggestion is, the teacher can ask students to individually write a short paragraph justifying how they did it to differentiate a two-syllable word from a three-syllable one.

9. Using various Sensory Channels, reinforces the memorization process.

Secret Syllables is in accordance with this guideline as it contains 5 challenges with different requests (decipher codes, select words from the table, build codes, discover words and build the respective codes). To reinforce diversified repetition, the teacher can, for example, add an exercise to provide an auditory stimulus. This exercise could be a song that addresses the names of animals or fruits and they had to code the names they heard.

10. Collaborative work encourages students' involve- ment and autonomy in their learning.

Secret Syllables does not conform to this guideline. The teacher can carry out this exercise in groups of two students, especially if it is to be applied with 2nd year students. This is because when the resource was applied in the classroom context, the 2nd year students experienced some difficulties. Furthermore, if the teacher uses the suggestion presented in guideline 5, he can build the concept map collaboratively in the classroom. The teacher can ask each student to contribute with one of the words he found.

Secret Syllables LR conforms to only two guidelines. With these guides we were able to contribute with suggestions for pedagogical practices and enrich the LR for the teacher to promote a more efficient training of Computational Thinking and word division skills. These guides inspired by Neuroed- ucation are intended to promote teaching and training of any content more effectively; they are not restricted to the area of CT training. In the next section, we present the conclusions and future work.

IV. Conclusion

All over the world, Computer Programming teachers see their efforts fail and recognize great difficulties in students when they need to solve problems using the computer, regard- less of the programming language adopted or the pedagogical methods followed.

In this context, Computer Scientists and Educators came to the conclusion that programming requires a set of skills that enable people to solve problems, in any area, in an adequate way. This skill set characterizes what is called, in honor of Wing, Computational Thinking (CT). Before starting to program, students must acquire these skills. To endow students with these skills, it is necessary to train them from childhood, as it is at younger ages that we can more easily “shape” the cognitive capacity of the brain. This training requires the use of appropriate Learning Resources (LR). However, support is needed for teachers to make training effective.

Knowing that Neuroeducation integrates Neuroscience, Psy- chology and Education theories to improve the quality of teaching and allow students to achieve lasting learning, we decided to study how it can give meaning to pedagogical practices already carried out, inspiring classroom practices that can provide teachers with the necessary guidance. The desired guidelines, which were presented and applied to the real case of the paper, allow for an evidence-based Education, using pedagogical strategies that respect the functioning of the brain, obtaining a more efficient teaching-learning process. These guidelines serve as a working tool for teachers to apply in their pedagogical practices and in LR, in order to obtain more effective training, in this case in CT. This LR in conjunction with the guides does not specifically train programming, but some of the cognitive processes to learn to program. It is important to point out that these guides are transversal to any subject that the teacher wants to teach and train.

As future work, we plan to go on exploring the Neuroedu- cation evidences to tune our guidelines and, maybe, come out with new ones. At last, it will be urgent to design and conduct experiments to assess the proposal. With the outputs of this project we intend to contribute to the enrichment of initial and continued teacher training.

ACKNOWLEDGMENT

This work has been supported by FCT-–Fundac¸a˜o para a Cie^ncia e Tecnologia within the R&D Units Project Scope: UIDB/00319/2020. The Ph.D. work of Cristiana Arau´jo is supported by FCT-–Fundac¸a˜o para a Cie^ncia e Tecnologia, Research Grant, with reference 2020.09845.BD.

REFERENCES

[1] J. M. Wing, “Computational thinking,” *Commun. ACM*, vol. 49, no. 3, p. 33–35, mar 2006.
[2] ISTE and CSTA, “Operational Definition of Computational Thinking for K–12 Education,” 2011, accessed: 2021-11- 07.
[3] Barefoot, “Computational Thinking Concepts and Approaches,” 2021, accessed: 2021-11-07.
[4] A. Mehta, “”neuroeducation”, emerges as insights into brain developmentk learning abilities grow.” *Brain Research*, vol. 16, no. 5, pp. 1–3, 2009.
[5] R. Hohl, “O cerebro aprendiz: neuroplasticidade e educac¸a˜o,” *Psicologia da Educac¸a˜o*, pp. 130–133, 2020.
[6] J. H. Berssanette and A. C. de Francisco, “Cognitive load theory in the context of teaching and learning computer programming: A systematic literature review,” *IEEE Transactions on Education*, vol. 65, no. 3, pp. 440–449, 2022.
[7] Y. Shin and D. Song, “The effects of self-regulated learning support on learners’ task performance and cognitive load in computer programing,” *Journal of Educational Computing Research*, vol. 60, no. 6, pp. 1490–1513, 2022.
[8] B. B. Morrison, “Using cognitive load theory to improve the efficiency of learning to program,” in *Proceedings of the Ninth Annual International ACM Conference on International Computing Education Research*, ser. ICER ’13. New York, NY, USA: Association for Computing Machinery, 2013, p. 183–184.
[9] M. T. R. van Kesteren and M. Meeter, “How to optimize knowledge construction in the brain,” *npj Science of Learning*, vol. 5, no. 1, p. 5, 2020.
[10] H. Eichenbaum, “Memory: Organization and control,” *Annual Review of Psychology*, vol. 68, no. 1, pp. 19–45, 2017.
[11] R. M. Cosenza, *Neurocie^ncia e Educac¸a˜o. Como o ce´rebro aprende.* Artmed Editora, 2011.
[12] S. Ngersawat and R. Kirkpatrick, “An investigation of act students’ english language problems and their learning strategies in grade 10 bilingual program,” *Procedia - Social and Behavioral Sciences*, vol. 98, pp. 1356–1365, 2014, proceedings of the International Conference on Current Trends in ELT.
[13] J. Sweller, “Cognitive load theory: Recent theoretical advances.” 2010.
[14] M. Mancinetti, S. Guttormsen, and C. Berendonk, “Cognitive load in internal medicine: What every clinical teacher should know about cognitive load theory.” *European journal of internal medicine*, vol. 60, pp. 4–8, 2019.
[15] S. Ghanbari, F. Haghani, M. Barekatain, and A. R. Jamali, “A systematized review of cognitive load theory in health sciences education and a perspective from cognitive neuroscience,” *Journal of Education and Health Promotion*, vol. 9, 2020.
[16] N. Schaefer, C. Rotermund, E.-M. Blumrich, M. V. Lourenco, P. Joshi, R. U. Hegemann, S. Jamwal, N. Ali, E. M. Garc´ıa Romero, S. Sharma, S. Ghosh, J. K. Sinha, H. Loke, V. Jain, K. Lepeta, A. Salamian, M. Sharma, M. Golpich, K. Nawrotek, R. K. Paidi, S. M. Shahidzadeh, T. Piermartiri, E. Amini, V. Pastor, Y. Wilson, P. A. Adeniyi, A. K. Datusalia, B. Vafadari, V. Saini, E. Sua´rez-Pozos, N. Kushwah, P. Fontanet, and A. J. Turner, “The malleable brain: plasticity of neural circuits and behavior – a review from students to students,” *Journal of Neurochemistry*, vol. 142, no. 6, pp. 790–811, 2017.
[17] A. San Martin, L. Rela, B. Gelb, and M. R. Pagani, “The spacing effect for structural synaptic plasticity provides specificity and precision in plastic changes,” *Journal of Neuroscience*, vol. 37, no. 19, pp. 4992–5007, 2017.
[18] F. H. Gage and A. R. Muotri, “What makes each brain unique,” *Scientific American*, vol. 306, no. 3, pp. 26–31, 2012.
[19] M. McDaniel, C. Fadler, and H. Pashler, “Effects of spaced versus massed training in function learning,” *Journal of experimental psychology. Learning, memory, and cognition,*, vol. 39, no. 5, p. 1417–1432, 2013.
[20] J. C. Wingard, J. Goodman, K.-C. Leong, and M. G. Packard, “Differential effects of massed and spaced training on place and response learning: A memory systems perspective,” *Behavioural Processes*, vol. 118, pp. 85–89, 2015.
[21] T. Abel, R. Havekes, J. M. Saletin, and M. P. Walker, “Sleep, plasticity and memory from molecules to whole-brain networks,” *Current Biology*, vol. 23, no. 17, pp. R774–R788, 2013.
[22] N. Lemos, J. Weissheimer, and S. Ribeiro, “Naps in school can enhance the duration of declarative memories learned by adolescents,” *Frontiers in Systems Neuroscience*, vol. 8, p. 103, 2014.
[23] S. Ribeiro and R. Stickgold, “Sleep and school education,” *Trends in Neuroscience and Education*, vol. 3, no. 1, pp. 18–23, 2014, 3rd Latin American Schools on Education and the Cognitive and Neural Sciences.
[24] M. T. R. van Kesteren, L. Krabbendam, and M. Meeter, “Integrating educational knowledge: reactivation of prior knowledge during educational learning enhances memory integration,” *npj Science of Learning*, vol. 3, no. 1, p. 11, 2018.
[25] M. L. Schlichting and A. R. Preston, “Memory integration: neural mechanisms and implications for behavior,” *Current Opinion in Behavioral Sciences*, vol. 1, pp. 1–8, 2015, cognitive control.
[26] Y. L. Shing and G. Brod, “Effects of prior knowledge on memory: Implications for education,” *Mind, Brain, and Education*, vol. 10, no. 3, pp. 153–161, 2016.
[27] S. McKenzie and H. Eichenbaum, “Consolidation and reconsolidation: Two lives of memories?” *Neuron*, vol. 71, no. 2, pp. 224–233, 2011.
[28] M. T. Van Kesteren, T. I. Brown, and A. D. Wagner, “Interactions between memory and new learning: insights from fmri multivoxel pattern analysis,” *Frontiers in systems neuroscience*, vol. 10, p. 46, 2016.
[29] A. Greve, E. Cooper, R. Tibon, and R. N. Henson, “Knowledge is power: Prior knowledge aids memory for both congruent and incongruent events, but in different ways.” *Journal of Experimental Psychology: General*, vol. 148, no. 2, p. 325, 2019.
[30] G. Agra, N. S. Formiga, P. S. d. Oliveira, M. M. L. Costa, M. d. G. M. Fernandes, and M. M. L. d. No´brega, “Analysis of the concept of meaningful learning in light of the ausubel’s theory,” *Revista brasileira de enfermagem*, vol. 72, pp. 248–255, 2019.
[31] M. T. van Kesteren, P. Rignanese, P. G. Gianferrara, L. Krabbendam, and M. Meeter, “Congruency and reactivation aid memory integration through reinstatement of prior knowledge,” *Scientific Reports*, vol. 10, no. 1, p. 4776, 2020.
[32] A. Tambini and L. Davachi, “Awake reactivation of prior experiences consolidates memories and biases cognition,” *Trends in Cognitive Sciences*, vol. 23, no. 10, pp. 876–890, 2019.
[33] C. Watagodakumbura, “Some useful pedagogical practices: Educational neuroscience perspective,” *Journal of Studies in Education*, vol. 5, no. 4, pp. 191–221, 2015.
[34] S. Edwards and N. Cooper, “Mind mapping as a teaching resource,” *The Clinical Teacher*, vol. 7, no. 4, pp. 236–239, 2010.
[35] N. L. Schroeder, J. C. Nesbit, C. J. Anguiano, and O. O. Adesope, “Studying and constructing concept maps: A meta-analysis,” *Educational Psychology Review*, vol. 30, pp. 431–455, 2018.
[36] J. Metcalfe and B. L. Schwartz, *The ghost in the machine: Self-reflective consciousness and the neuroscience of metacognition.* Oxford handbook of metamemory, 2016.
[37] A. Ardila, “Is “self-consciousness” equivalent to “executive function”?” *Psychology & Neuroscience*, vol. 9, no. 2, p. 215, 2016.
[38] C. M. Roebers, “Executive function and metacognition: Towards a unifying framework of cognitive self-regulation,” *Developmental Review*, vol. 45, pp. 31–51, 2017.
[39] R. Ritchhart, M. Church, and K. Morrison, *Making thinking visible: How to promote engagement, understanding, and independence for all learners*. John Wiley & Sons, 2011.
[40] X. Lin-Siegler, C. S. Dweck, and G. L. Cohen, “Instructional interventions that motivate classroom learning.” *Journal of Educational Psychology*, vol. 108, pp. 295–299, 2016.
[41] L. Meng and Q. Ma, “Live as we choose: The role of autonomy support in facilitating intrinsic motivation,” *International Journal of Psychophysiology*, vol. 98, no. 3, Part 1, pp. 441–447, 2015.
[42] E. A. Patall, H. Cooper, and J. C. Robinson, “The effects of choice on intrinsic motivation and related outcomes: a meta-analysis of research findings.” *Psychological bulletin*, vol. 134, no. 2, p. 270, 2008.
[43] D. A. Sousa, *How the Brain Learns*, 6th ed. SAGE Publications, 2022.
[44] E. Rosegard and J. Wilson, “Capturing students’ attention: An empirical student,” *Journal of the Scholarship of Teaching and Learning*, vol. 13, no. 5, p. 1–20, Sep. 2013.
[45] M. J. Gruber, B. D. Gelman, and C. Ranganath, “States of curiosity modulate hippocampus-dependent learning via the dopaminergic circuit,” *Neuron*, vol. 84, no. 2, pp. 486–496, 2014.
[46] L. Buhry, A. H. Azizi, and S. Cheng, “Reactivation, replay, and preplay: how it might all fit together,” *Neural plasticity*, vol. 2011, 2011.
[47] E. M. Robertson and L. Genzel, “Memories replayed: reactivating past successes and new dilemmas,” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 375, no. 1799, p. 20190226, 2020.
[48] M. T. R. van Kesteren and M. Meeter, “How to optimize knowledge construction in the brain,” *npj Science of Learning*, vol. 5, no. 1, p. 5, 2020.
[49] L. R. Squire, L. Genzel, J. T. Wixted, and R. G. Morris, “Memory consolidation,” *Cold Spring Harbor perspectives in biology*, vol. 7, no. 8, p. a021766, 2015.
[50] M. T. H. Chi, “Active-constructive-interactive: A conceptual framework for differentiating learning activities,” *Topics in Cognitive Science*, vol. 1, no. 1, pp. 73–105, 2009.
[51] S. Denervaud, E. Gentaz, P. J. Matusz, and M. M. Murray, “Multisensory gains in simple detection predict global cognition in schoolchildren,” *Scientific reports*, vol. 10, no. 1, p. 1394, 2020.
[52] D. Clewett, S. DuBrow, and L. Davachi, “Transcending time in the brain: How event memories are constructed from experience,” *Hippocampus*, vol. 29, no. 3, pp. 162–183, 2019.
[53] L. Shams and A. R. Seitz, “Benefits of multisensory learning,” *Trends in Cognitive Sciences*, vol. 12, no. 11, pp. 411–417, 2008.
[54] H. J. Broadbent, T. Osborne, D. Mareschal, and N. Z. Kirkham, “Withstanding the test of time: Multisensory cues improve the delayed retention of incidental learning,” *Developmental Science*, vol. 22, no. 1, p. e12726, 2019.
[55] N. van Atteveldt, M. M. Murray, G. Thut, and C. E. Schroeder, “Multisensory integration: Flexible use of general operations,” *Neuron*, vol. 81, no. 6, pp. 1240–1253, 2014.
[56] A. N. Meltzoff, P. K. Kuhl, J. Movellan, and T. J. Sejnowski, “Foundations for a new science of learning,” *Science*, vol. 325, no. 5938, pp. 284–288, 2009.
[57] D. Blazar and M. A. Kraft, “Teacher and teaching effects on students’ attitudes and behaviors,” *Educational Evaluation and Policy Analysis*, vol. 39, no. 1, pp. 146–170, 2017.
[58] M. H. Immordino-Yang and L. Sylvan, “Admiration for virtue: Neuroscientific perspectives on a motivating emotion,” *Contemporary Educational Psychology*, vol. 35, no. 2, pp. 110–115, 2010, special Issue on “Brain Research, Learning, and Motivation”.
[59] U. Frith and C. Frith, “The social brain: allowing humans to boldly go where no other species has been,” *Philosophical Transactions of the Royal Society B: Biological Sciences*, vol. 365, no. 1537, pp. 165–76, 2010.
[60] B. Hurst, R. R. Wallace, and S. B. Nixon, “The impact of social interaction on student learning,” *Reading Horizons*, vol. 52, no. 4, pp. 165–176, 2013.
[61] H. Xue, K. Lu, and N. Hao, “Cooperation makes two less-creative individuals turn into a highly-creative pair,” *NeuroImage*, vol. 172, pp. 527–537, 2018.
[62] I. Clark and G. Dumas, “Toward a neural basis for peer-interaction: what makes peer-learning tick?” *Frontiers in psychology*, vol. 6, p. 28, 2015.
[63] R. Chandra, “Collaborative learning for educational achievement,” *IOSR Journal of Research & Method in Education (IOSR-JRME)*, vol. 5, no. 2, pp. 4–7, 2015.

UN RASTREADOR PARA LA FORMACIÓN DEL PROFESORADO EN EL LENGUAJE SCRATCHJR

J. Ángel Velázquez-Iturbide
Escuela Técnica Superior de Ingeniería Informática
Universidad Rey Juan Carlos
Móstoles, Madrid, España
angel.velazquez@urjc.es

David de Vicente Peña
Escuela Técnica Superior de Ingeniería Informática
Universidad Rey Juan Carlos
Móstoles, Madrid, España
d.devicente.2018@alumnos.urjc.es

Eva López Puente
Escuela Técnica Superior de Ingeniería Informática
Universidad Rey Juan Carlos
Móstoles, Madrid, España
e.lopezpu@alumnos.urjc.es

***Resumen*—Los lenguajes basados en bloques tienen características que facilitan el aprendizaje de la programación. Los futuros maestros deberían tener unas competencias básicas de informática y programación, como sucede en otras materias. Dichas competencias deben incluir conceptos y habilidades de programación, incluyendo la depuración de programas. Sin embargo, los entornos para lenguajes basados en bloques no incluyen mecanismos que permitan controlar la ejecución de un programa. Ante estas carencias, se presenta un rastreador del lenguaje ScratchJr, implementado como una ampliación de su entorno de programación. Sus facilidades principales son: mostrar los valores de los atributos de los personajes, varios controles del avance de la ejecución, mostrar el número de iteración de los bucles con contador, y mostrar simultáneamente los guiones en ejecución de todos los personajes.**

***Palabras clave*—lenguajes basados en bloques, ScratchJr, formación del profesorado, semántica operacional, rastreador**

I. INTRODUCCIÓN

En la última década se ha asentado la programación basada en bloques como un paradigma a tener en cuenta en la enseñanza de la programación [1]. Aunque existen experiencias en la universidad [2], su uso se concentra principalmente en las etapas preuniversitarias, es decir Educación Infantil [3][4], Primaria [5] y Secundaria [6].

Uno de los problemas principales para la introducción generalizada de la informática en general y la programación en particular en el currículo escolar es la falta de formación del profesorado [7]. Es una carencia que no tiene una solución clara a corto plazo, pero que debe afrontarse pensando a medio y largo plazo. La solución dependerá de las peculiaridades de cada país en el acceso a la profesión docente.

En España [8], los profesores de Educación Infantil y Primaria se forman en los grados respectivos. Asimismo, los profesores de Educación Secundaria deben cursar el *Máster* Universitario en Formación del *Profesorado* de Educación Secundaria, Bachillerato, FP e Idiomas. Normalmente, dicho máster ofrece un itinerario en Tecnología, pero pocos lo ofrecen en Informática o en Tecnología e Informática.

Un profesor bien formado para enseñar cierta materia debe tener conocimiento de la misma, así como conocimiento de su didáctica e instrumentación [9]. El conocimiento del contenido suele darse por supuesto en cualquier profesor, pero no siempre es así. Por ejemplo, un profesor que debe sustituir a otro por una baja puede tener lagunas en su conocimiento de la nueva materia a impartir. En el caso de la informática, esta situación no es anecdótica, sino generalizada. Al ser una materia que no se incluye en los grados de Educación ni suele incluirse en el Máster Universitario de Formación del *Profesorado*, el conocimiento de informática y programación suele ser nulo o, con suerte, superficial.

Este trabajo se ha financiado con dos proyectos-puente de la Universidad Rey Juan Carlos (M2614 y M3035) y el proyecto PROGRAMA del Ministerio de Ciencia e Innovación (ref. PID2022-137849OB-I00).

El aprendizaje de la programación no es sencillo, como ha quedado constatado en innumerables investigaciones (véase, por ejemplo, las revisiones [10][11][12]). Es cierto que la programación basada en bloques facilita el aprendizaje de la programación porque elimina algunas de las dificultades del aprendizaje de la programación, como la memorización de las construcciones del lenguaje o la comprensión de los mensajes de compilación.

Sin embargo, persisten otras dificultades, como comprender la dinámica de la ejecución de los programas, necesaria para depurar programas con errores. La dinámica de los programas se explica mediante modelos conceptuales explícitos o implícitos, frecuentemente llamados “máquinas nocionales” [13][14]. Actualmente, no existe ninguna máquina nocional claramente especificada para lenguajes basados en bloques [15].

En esta comunicación abordamos el desarrollo de herramientas de programación que faciliten a los profesores el aprendizaje de la dinámica de los lenguajes basados en bloques. En concreto, se presenta una ampliación del entorno de programación de ScratchJr para facilitar el rastreo (*trace*) de la ejecución de sus programas, de forma parecida a los depuradores de lenguajes textuales. Dicha ampliación permite mostrar el estado de un programa en ejecución y controlar su avance.

La estructura de la comunicación es la siguiente. En la sección segunda se presentan las características principales del lenguaje ScratchJr. La sección tercera presenta las modificaciones realizadas en el entorno de programación de ScratchJr. Finalmente, presentamos nuestras conclusiones y trabajos futuros.

II. SCRATCHJR

ScratchJr [16] es un lenguaje de programación visual diseñado para introducir en la programación a niños de 5 a 7 años de edad. ScratchJr es un derivado del popular lenguaje Scratch [17] que permite programar sin necesidad de saber leer. Puede encontrarse más información en su página web (https://www.scratchjr.org/). Veamos en esta sección una breve introducción al lenguaje y su entorno.

A. Programas ScratchJr

La Fig. 1 muestra la pantalla principal de ScratchJr. Podemos identificar varias zonas:

- Escenario. Está situada en la parte central de la pantalla y es el área donde transcurre la acción. En la figura, pueden verse un gato y un pollo en una dehesa.
- Páginas. Esta zona está situada en la parte superior derecha y muestra los distintos fondos en los que transcurrirá la acción del programa. En la figura se muestra la única página existente (el paisaje) más la posibilidad de añadir otras páginas (signo más).
- Personajes. Esta zona está situada en la parte superior izquierda y muestra los personajes de la página actual del programa. La etiqueta del personaje que se encuentra seleccionado aparece agrandada y resaltada en naranja (en la figura, el gato).
- Controles. Encima del escenario aparecen varios controles, entre ellos la bandera verde que se utiliza para iniciar la ejecución de un programa.
- Zona de programación. En esta zona situada en la parte inferior de la pantalla, se construye el programa del personaje seleccionado. Su programa puede estar formado por varias secuencias de bloques ("guiones", *scripts*) que pueden ejecutarse en paralelo. Obsérvese en la figura que los bloques de un guion se disponen en horizontal, de izquierda a derecha.
- Categorías y paleta de bloques. El escenario y la zona de programación están separadas por una franja horizontal. En su parte izquierda aparecen seis iconos que representan las seis categorías de bloques. A su derecha, aparecen los bloques disponibles de la categoría seleccionada. En la figura, se muestran los ocho bloques de la categoría de movimiento (color azul).

Fig. 1. Pantalla principal de ScratchJr

Un programa está formado por los guiones de los personajes de todas las páginas. Un personaje tiene cero, uno o varios guiones (véase el gato de la Fig. 1, con dos guiones). Cada guion se crea arrastrando bloques desde la paleta de bloques a la zona de programación y particularizando los parámetros del bloque, si los tiene.

Existen seis categorías de bloques, cada una distinguible mediante un color:

- Bloques de movimiento (color azul).
- Bloques de apariencia (color rosa).
- Bloques de sonido (color verde).
- Bloques disparadores (color amarillo).
- Bloques de control (color naranja).
- Bloques de finalización (color rojo).

Las dos primeras categorías permiten mover o cambiar el aspecto de los personajes. La tercera categoría permite reproducir sonidos. Las restantes tres categorías contienen bloques de control, que deben colocarse en partes distintas de un programa ScratchJr: los bloques disparadores se colocan al comienzo de un guion, los bloques de finalización se colocan al final y los bloques de control, en medio. La forma de cada tipo de bloques está adaptada a este fin.

B. Ejecución de ScratchJr

Un programa ScratchJr comienza a ejecutarse cuando se produce un evento que es capturado por uno o varios guiones de la primera página. Hay cuatro tipos de evento:

- Al presionar la bandera verde.
- Al pulsar al personaje.
- Al recibir un mensaje.
- Al tocar al personaje.

Normalmente, la ejecución de un programa suele comenzar cuando el usuario pulsa el icono de bandera verde. Una vez que se pulsa la bandera verde, su icono es sustituido por un icono de hexágono rojo, que podrá pulsarse para parar la ejecución. En ese momento, se restaura el icono de bandera verde.

La ejecución comienza en la primera página. Puede cambiarse de página cuando se ejecuta el bloque de finalización “Ir a página”. Este bloque produce un cambio de fondo en el escenario, la desaparición de todos los personajes de la página anterior y la aparición de los personajes de la nueva página. Obviamente, se para la ejecución de los guiones activos de los personajes de la página anterior y se inician los guiones de los nuevos personajes que tengan un bloque disparador “Al presionar bandera verde”. Por tanto, las páginas delimitan el ámbito de fondos, personajes y guiones.

Dentro de una página, puede haber varios guiones ejecutándose en paralelo. Cada guion inicia su ejecución cuando se cumple la condición de su bloque disparador. Por tanto, el número de guiones que se ejecutan en paralelo en un programa ScratchJr puede variar en el tiempo. Si suponemos que el programa se ejecuta con un solo “procesador”, esto implica que los bloques de los distintos guiones activos se ejecutan de alguna forma alterna y equitativa.

Los bloques de un guion se ejecutan secuencialmente. Los bloques de las categorías de movimiento, apariencia y sonido son sencillos de comprender, ya que su efecto es visible (en los dos primeros casos) o audible (en el tercero). Son más complejos de comprender los bloques de control, repartidos entre las categorías de bloques disparadores (basadas en eventos, ya examinados), de control y terminadores (que incluye el bloque “Ir a página”, entre otros).

Los bloques de control permiten cambiar la ejecución secuencial de un guion. El bloque terminador “Repetir indefinidamente” introduce todo el guion en un bucle infinito. El bloque “Repetir” es un bucle con contador, es decir, hace que los bloques que agrupa se repitan tantas veces como indica su número asociado, que es modificable por el usuario. La ejecución del bloque “Parar” en un guion de un personaje produce la interrupción de los demás guiones del personaje. Finalmente, tenemos dos bloques de control que permiten actuar sobre el comportamiento temporal de los personajes. El bloque “Esperar” provoca que la ejecución de un guion se pare durante varias décimas de segundo. El bloque “Fijar velocidad” permite variar la velocidad de los movimientos de un personaje.

En total, el lenguaje incluye 28 bloques distintos, aunque algunos son parametrizables mediante colores, números o sonidos. Aunque muchos bloques tienen un comportamiento sencillo de comprender, otros son más complejos o incluso tienen comportamientos imprevistos en algunas situaciones [18]. Por tanto, un rastreador puede mejorar la comprensión de la ejecución de los programas ScratchJr.

III. Un Rastreador de ScratchJr

En esta sección presentamos las principales modificaciones realizadas sobre el entorno de ScratchJr.

C. *Atributos de un Personaje*

En ScratchJr no existen variables. Sin embargo, cada personaje tiene ciertos atributos cuyos valores son parte del estado del programa, junto con información de control de su ejecución (página activa, guiones activos, etc. [18]).

Una primera ampliación fue hacer visibles los valores de los atributos de cada personaje, ya que algunos eran fácilmente determinables de forma visual, pero otros no. La Fig. 2 muestra que cada personaje tiene 8 atributos, cuyo valor puede consultarse entre la zona de personajes y el escenario, para que la consulta visual sea rápida (el escenario no se muestra en la figura). En cada momento, se presentan solamente los valores de los atributos del personaje activo (en la figura, el personaje de color morado llamado Te). Obsérvese que algunos atributos, que sólo toman dos valores, se muestran mediante iconos.

Fig. 2. Atributos de los personajes

Los atributos mostrados son los siguientes. Algunos valores son los que tiene internamente el procesador de ScratchJr, mientras que otros se han adaptado para que sean comprensibles por el usuario.

- Posición *y*, es decir, su posición vertical. Se utiliza el criterio espacial de ScratchJr, con el escenario dividido en filas numeradas, de abajo a arriba, de 1 a 15.
- Posición *x*, es decir, su posición horizontal. Análogamente, las columnas están numeradas de izquierda a derecha de 1 a 20.
- Orientación, a la derecha o a la izquierda.
- Ángulo, comprendido entre 0 y 359 grados.
- Visibilidad, es decir, si el personaje es visible o no.
- Escala, cuyo valor se adapta a cada personaje, de forma que recoge su tamaño relativo entre el mínimo y el máximo posible (1% y 100%, respectivamente).
- Diálogo, que indica si el personaje está hablando.
- Velocidad del personaje, con valores 25, 50 y 100, correspondientes a velocidades lenta, media y rápida, respectivamente.

Los campos de atributo no sólo muestran sus valores, sino que permiten modificarlos. La interacción varía según el atributo:

- Posición *y*, posición *x*. Deben modificarse manipulando la posición del personaje directamente en el escenario o ejecutando bloques de movimiento.
- Orientación, visibilidad. Al ser campos booleanos, cambian de un valor al contrario si se hace clic directamente sobre el campo correspondiente.

- Ángulo, escala, velocidad. En la Fig. 2 puede observarse que existen dos controles a la derecha de estos campos, uno para aumentar y otro para disminuir. Para los tres atributos, las variaciones coinciden con las que se obtendrían con el bloque correspondiente. Por ejemplo, un tic de aumento o disminución produce un giro a derecha o a izquierda de 30º, respectivamente.
- Diálogo. Sólo puede modificarse mediante la ejecución de un bloque "Decir".

D. Bloque "Repetir"

Un bloque de control destacado es el bloque "Repetir". Sin embargo, durante su ejecución, no se sabe cuántas iteraciones lleva realizadas. Para que se conozca el estado de ejecución del bloque "Repetir", cuando comienza la ejecución del guion en el que se encuentra, se hace visible un contador interno.

La Fig. 3 muestra los sucesivos estados de la ejecución paso a paso de un guion consistente simplemente en un paso a la derecha seguido de un bucle que repite dos veces un bloque "Crecer".

Veamos su explicación paso a paso:

- Figura 3(a): muestra el guion antes de iniciar la ejecución.
- Figura 3(b): se ejecuta y resalta el primer bloque, "Mover a la derecha". Dado que el guion contiene un bloque "Repetir", también aparece el contador del bucle, sin tomar ningún valor todavía.
- Figura 3(c): se ejecuta la primera iteración del bucle, ya que engloba un solo bloque, "Aumentar".
- Figura 3(d): se ejecuta la segunda iteración del bucle.

Si avanzáramos un paso más, saldría del bucle y terminaría la ejecución del guion. El guion volvería a presentar el mismo aspecto que en la Fig. 3(a).

E. Modos de Avance

Recordemos que los únicos controles disponibles en ScratchJr para controlar la ejecución de un programa son el icono de bandera verde para comenzar y el hexágono rojo para terminar. La Fig. 4 muestra cinco controles adicionales, que se han situado junto a la bandera verde (y el hexágono rojo).

Veamos la función de cada control nuevo, de arriba abajo y de izquierda a derecha en la Fig. 4:

- Avanza hasta chocar. La ejecución del programa avanza hasta que un bloque disparador detecta un evento de "Al tocar al personaje", es decir, cuando dos personajes chocan.
- Avanza un paso. El programa del personaje activo avanza un paso, es decir, se ejecuta un bloque de cada guion activo de dicho personaje.
- Avanza hasta mensaje. La ejecución del programa avanza hasta que un bloque disparador detecta un evento de "Al recibir mensaje".
- Avanzan todos un paso. Los programas de todos los personajes avanzan un paso.

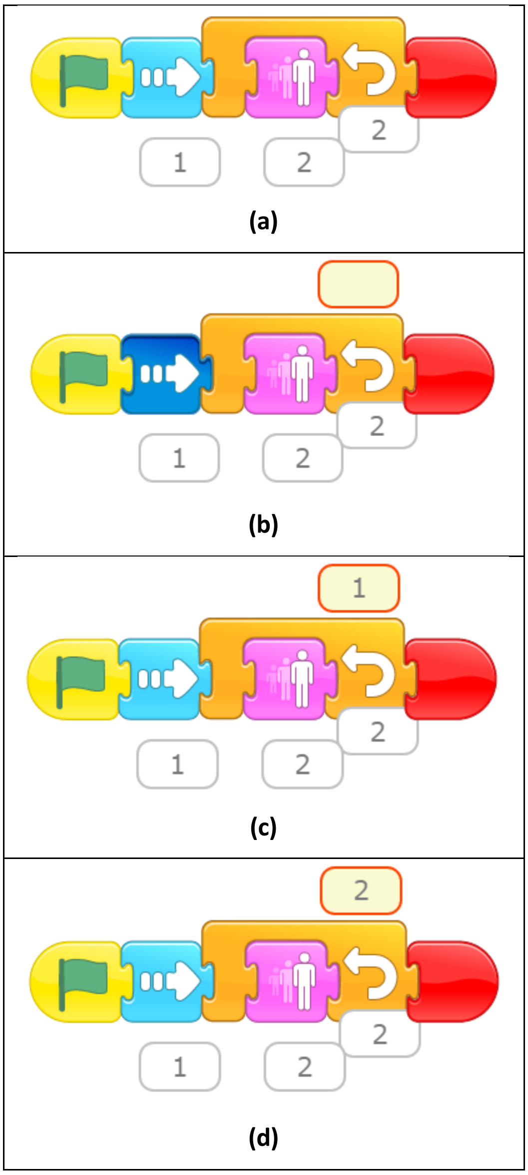


Fig. 3. Estados sucesivos de la ejecución de un bucle con dos iteraciones

Fig. 4. Controles para el avance de la ejecución

- Avanza hasta el final. Este icono no aparece inicialmente, pero se hace visible cuando el usuario presiona alguno de los otros iconos. Su uso supone que la ejecución deja de estar controlada por el usuario.

Se mantiene el efecto visual de ScratchJr consistente en que el bloque que se acaba de ejecutar se resalta con un tono más oscuro. Esto facilita su identificación.

La introducción de los controles de avance se ha realizado respetando la semántica operacional del lenguaje, es decir, no se ha alterado la ejecución de ningún bloque de ScratchJr. Sin embargo, una curiosa irregularidad de ScratchJr es que algunos bloques se ejecutan pero nunca se resaltan sus bloques, dando la impresión de que no consumen tiempo de ejecución. Es el caso del bloque ”Repetir”, cuyo control no se tiene en cuenta en la planificación de la ejecución. Por tanto, durante un avance paso a paso, el bloque no se resalta ni su ejecución cuenta como un paso.

F. Pantalla de Rastreo Simultáneo

Las facilidades presentadas en los subapartados anteriores se han integrado en la pantalla principal de ScratchJr (Fig. 1), modificando ligeramente la ubicación de algunos elementos y añadiendo otros nuevos. También se ha añadido un icono que permite acceder a una pantalla en la que se muestran simultáneamente los programas de todos los personajes. De esta forma, se puede tener una visión global del avance de la ejecución del mismo.

La Fig. 5 muestra esta pantalla para un programa con tres personajes. Obsérvese que se mantienen todas las funciones de la pantalla principal, salvo la edición de programas. Ante la ejecución del programa, se muestra el avance de la misma en todos los guiones.

El usuario puede hacer activo a cualquier personaje con clicar en su zona de programa. Como consecuencia, sus guiones se muestran con colores no difuminados y se presentan los valores de sus atributos. En la figura, está seleccionado el personaje de color azul.

El icono X de la esquina superior izquierda permite volver a la pantalla principal y la flecha de la parte inferior permite que la ejecución salte a la página siguiente. Por tanto, proporciona otra función de control de la ejecución. Si hubiera una página anterior, aparecería una flecha parecida en la esquina inferior izquierda, pero orientada a la izquierda.

G. Interfaz de Usuario

Al modificar el entorno de programación de ScratchJr, se cuidó que los cambios fueran coherentes, dentro de lo posible, con el diseño de su interfaz de usuario. Esto se refleja en el diseño o selección de iconos y colores.

Los atributos de los personajes han presentado una dificultad añadida. ScratchJr está pensado para niños pequeños, probablemente prelectores [16]. Por esta razón, su interfaz prescinde casi completamente de texto. En un primer momento, se pretendió realizar algo parecido con los atributos. Sin embargo, era difícil distinguir los atributos y sus valores. Dado que el rastreador está concebido para profesores, finalmente se decidió poner el nombre cada atributo. Por coherencia, el rastreador los muestra en el idioma activo (ScratchJr soporta 12 idiomas).

H. Disponibilidad y Limitaciones

El rastreador se ha desarrollado a partir de una versión de ScratchJr disponible para escritorio[10]. Dado que el rastreador aún no ha sido evaluado, no está disponible públicamente, pero se puede obtener si se solicita a los autores de la comunicación.

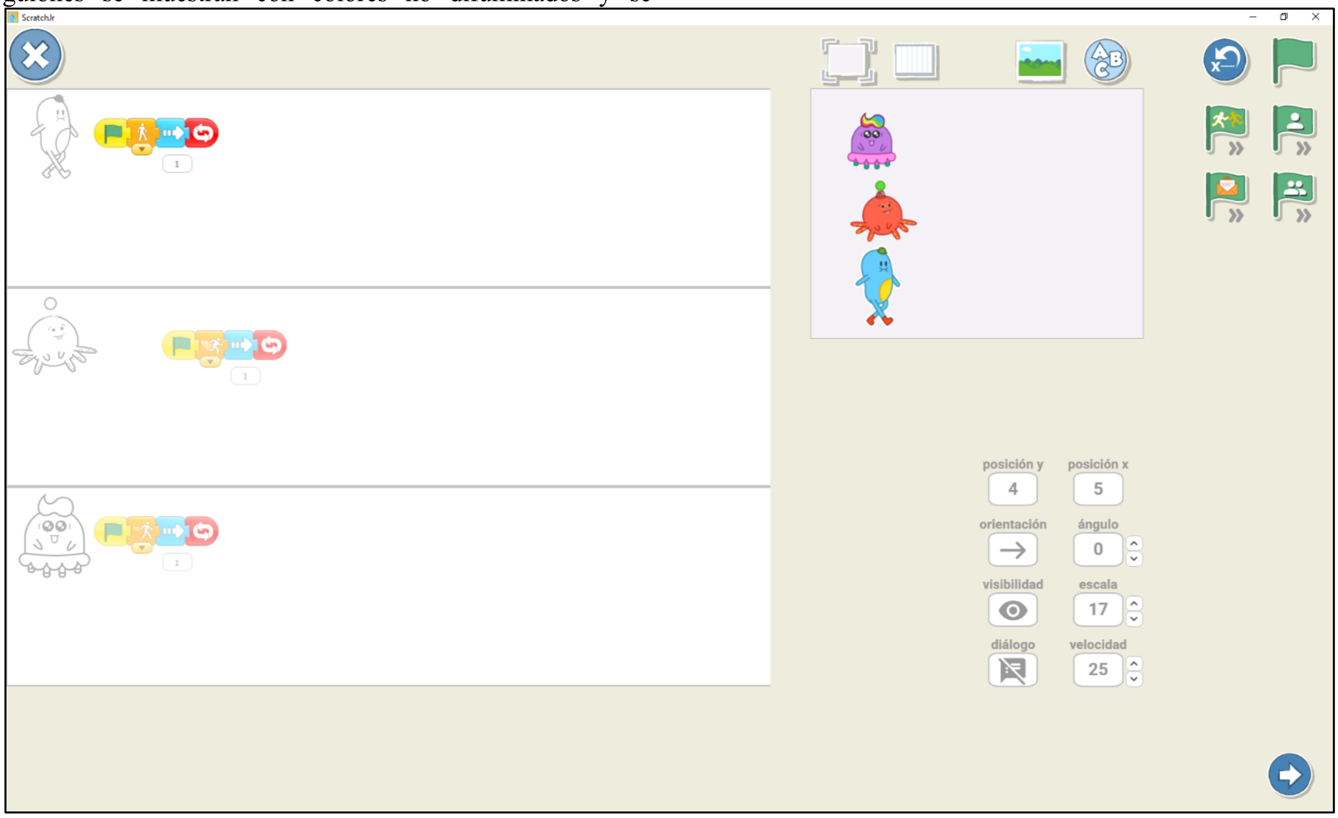


Fig. 5. Pantalla en la que se muestran simultáneamente todos los guiones antes de iniciar la ejecución

[10] Descripción: https://jfo8000.github.io/ScratchJr-Desktop/.
Implementación: https://github.com/jfo8000/ScratchJr-Desktop/.

Los avances permitidos por el rastreador son limitados, ya que sólo permite avanzar paso a paso o hasta que ocurre un evento (análogamente a los puntos de ruptura de depuradores para lenguajes tradicionales).

El rastreador permite controlar el avance de la ejecución, sin alterar el comportamiento global del programa, salvo en tres casos. Primero, mediante el avance repetido de un paso de un solo personaje. En esta situación, se altera el comportamiento del programa porque la ejecución de los demás personajes no avanza. Segundo, cuando varios personajes se mueven a distintas velocidades. En esta situación, la intervención humana interfiere ya que no permite mostrar el efecto de las distintas velocidades. Tercero, desde la pantalla con todos los guiones puede saltarse a la página anterior o siguiente. Esto produce un cambio en el flujo de la ejecución no previsto en el código del programa.

IV. Conclusiones

Hemos presentado un rastreador de programas ScratchJr, cuyo objetivo es facilitar a los profesores la comprensión de la ejecución de los programas ScratchJr y facilitar su depuración. Aunque ScratchJr se utiliza principalmente en Educación Infantil, la herramienta también puede resultar útil a profesores de otras etapas educativas que aprendan ScratchJr como primer lenguaje de programación [19].

Como trabajos futuros se prevé evaluar su utilidad percibida y aceptación por parte de profesores en formación o en activo [19]. También se prevé realizar otras mejoras. Primero, pueden añadirse más facilidades que permitan un control más fino de la ejecución de los programas. Podrían añadirse otros tipos de avance o permitir la selección de otros bloques como puntos de ruptura. Esta ampliación choca con el diseño minimalista de ScratchJr, ya que un aumento de la funcionalidad puede redundar en menos usabilidad [20], pero puede ser aceptable si ayuda a los profesores a comprender mejor la programación. Segundo, podría modificarse ligeramente la semántica operacional del propio lenguaje para conseguir homogeneidad, de forma la ejecución de cualquier bloque siempre sea un paso de la ejecución del programa.

Referencias

[1] D. Bau, J. Gray, C. Kelleher, J. Sheldon y F. Turbak, "Learnable programming: Blocks and beyond," Communications of the ACM, vol. 60, no. 6, pp. 72-80, junio 2017, DOI 10.1145/3015455.

[2] J. A. Martínez-Valdés, J. Á. Velázquez-Iturbide y R. Hijón-Neira, "A (relatively) unsatisfactory experience of use of Scratch in CS1," en Proceedings of 5th International Conference on Technological Ecosystems for Enhancing Multiculturality, TEEM'07, ACM DL, 2017, 6 pp., DOI 10.1145/3144826.3145356.

[3] E. Macrides, O. Miliou y C. Angeli., "Programming in early childhood education: A systematic review," International Journal of Child-Computer Interaction, vol. 32, 100396, 2022, DOI 10.1016/j.ijcci.2021.100396.

[4] C. S. González González, "Estado del arte en la enseñanza del pensamiento computacional y la programación en la etapa infantil," Education in the Knowledge Society, vol. 20, 2019, DOI 10.14201/eks2019_20_a17.

[5] J. Fagerlund, P. Häkkinen, M. Vesisenaho y J. Viiri, "Computational thinking in programming with Scratch in primary schools: A systematic review," Computer Applications in Engineering Education, vol. 29, pp. 12-28, 2020, DOI 10.1002/cae.22255.

[6] J. Lockwood y A. Mooney, "Computational thinking in secondary education: Where does it fit? A systematic literary review," International Journal of Computer Science Education in Schools, vol. 2, no. 1, enero 2018, DOI 10.21585/ijcses.v2i1.26.

[7] M. E. Carpensen, J. Gal-Ezer, A. McGettrick y E. Nardelli, Informatics for All. The Strategy. ACM Europe & Informatics Europe, 2018. Recuperado de https://cutt.ly/zYh1Ze0.

[8] J. Ángel Velázquez Iturbide, F. Llorens Largo, D. López Álvarez y Mercedes Marqués Andrés, "Informe CODDII/SCIE sobre formación del profesorado y didáctica de la informática en etapas preuniversitarias," 2023. Recuperado de https://onx.la/c025d.

[9] M. J. Koehler y P. Mishra, "What is technological pedagogical content knowledge?," Contemporary Issues in Technology and Teacher Education, vol. 9, no. 1, pp. 60-70, 2009.

[10] A. B. Robins, "Novice programmers and introductory programming," en The Cambridge Handbook of Computing Education Research, S. A. Fincher y A. V. Robins, Eds., Cambridge University Press, 2019, pp. 327-376.

[11] A. Gomes y A. J. Mendes, "Learning to program - difficulties and solutions," en Proceedings of the International Conference on Engineering Education, ICEE 2007,. Coimbra, Portugal: Academic Press, 2007.

[12] A. Luxton-Reilly, Simon, I. Albluwi, B. A. Becker, M. Giannakos, A. N. Kumar, L. Ott, J. Paterson, M. J. Scott, J. Sheard y C. Szabo, "Introductory programming: A systematic literature review," en ITiCSE'18 Companion, ACM DL, pp. 55-106, DOI 10.1145/3293881.3295779.

[13] J. Sorva, "Notional machines and introductory programming education", ACM Transactions on Computing Education, vol. 13, no. 2, article 8, 2013, DOI 10.1145/2483710.2483713.

[14] B. du Boulay, T. O'Shea y J. Monk, "The black box inside the glass box: Presenting computing concepts to novices", International Journal of Man-Machine Studies, vol. 14, no. 3, pp. 237-249, 1981, DOI 10.1016/S0020-7373(81)80056-9.

[15] O. Seppälä, T. Ball, T. Barik, B. A. Becker, P. Denny, R. Duran, J. Sorva y J. Á. Velázquez-Iturbide, "Notional machines for Scratch and Python," en M. Guzdial, S. Krishnamurthi, J. Sorva y J. Vahrenhold, Eds., "Notional machines and programming language semantics in education", Dagstuhl Reports, vol. 9, no. 7, 2019, Dagstuhl Publishing, p. 21, DOI 10.4230/DagRep.9.7.1.

[16] L. P. Flannery, E. R. Kazakoff, P. Bontá, B. Silverman, M. U. Bers y M. Resnick, "Designing ScratchJr: Support for early childhood learning through computer programming," en Proceedings of the 12th International Conference on Interaction Design and Children, IDC '13, pp. 1-10, DOI 10.1145/2485760.2485785.

[17] M. Resnick, J. Maloney, A. Monroy-Hernández, N. Rusk, E. Eastmond, K. Brennan, A. Millner, E. Rosenbaum, J. Silver, B. Silverman e Y. Kafai, "Scratch: Programming for all," Communications of the ACM, vol. 52, no. 11, pp. 60–67, nov. 2009, 10.1145/1592761.1592779.

[18] J. Á. Velázquez-Iturbide, "Towards the design of notional machines for simple block-based languages," en Proceedings of the International Symposium on Computers in Education, SIIE'21, A. Balderas, A. Mendes y J. M. Dodero (eds.), IEEE Xplore, 2021, 6 pp., DOI 10.1109/SIIE53363.2021.9583645.

[19] M. Paredes Velasco y J. Á. Velázquez Iturbide, "Una asignatura para la formación del profesorado en programación mediante lenguajes basados en bloques," Actas de las JENUI 2022, vol. 7, pp. 337-344. Recuperado de https://aenui.org/actas/pdf/JENUI_2022.pdf.

[20] J. Á. Velázquez-Iturbide, A. Pérez-Carrasco y Ouafae Debdi, "Experiences in usability evaluation of educational programming tools,", en STEM Education: Concepts, Methodologies, Tools, and Applications, IGI Global, 2015, pp. 461-480, DOI 10.4018/978-1-4666-7363-2.ch025.

A Study on the Motivation of Computer Science Students to Learn Programming

Leonardo Silva
CISUC - Department of Informatics Engineering of University of Coimbra
Coimbra, Portugal
leonardo.silva@garanhuns.ifpe.edu.br

Anabela Gomes
Polytechnic Institute of Coimbra, ISEC
CISUC— Department of Informatics Engineering, University of Coimbra
Coimbra, Portugal
anabela@isec.pt

Ana Rosa Borges
Polytechnic Institute of Coimbra, ISEC
Coimbra, Portugal
arborges@isec.pt

Verónica Vasconcelos
Polytechnic Institute of Coimbra, ISEC
Coimbra, Portugal
INESC TEC - Porto
veronica@isec.pt

António José Mendes
CISUC— Department of Informatics Engineering, University of Coimbra
Coimbra, Portugal
toze@dei.uc.pt

***Abstract*— This work focuses on the motivation levels of introductory programming students and their relationship with their learning performance. The study involved students enrolled in the Introduction to Programming (IP) course included in two slightly different Informatics Engineering degrees at the same institution. The motivation section of the Motivated Strategies for Learning Questionnaire (MSLQ) instrument includes several scales and subscales used to analyse different motivational factors.**

Four research questions guided the study. The first is comparing the results of the two groups of students. The second considered the student's previous programming experience and tried correlating it with motivational factors. The third is similar but separates students following IP for the first time and those who had failed it in previous years. Finally, the fourth research question examined the influence of motivational factors on students' learning performance measured by their final grades.

This paper provides a detailed study description and presents and discusses its results.

Keywords*— *Motivational levels, MSQL, Higher Education, CS1

I. Introduction

Programming education is an essential topic in computing degrees. However, learning programming can be challenging, leading to anxiety and frustration for many students [1]. To promote effective learning, it is crucial to investigate the factors that influence the programming learning process. This can provide a basis for researchers and educators to develop interventions that effectively support students' learning. One of these factors is motivation. It is relevant to know how motivation levels affect programming students' performance and how student motivation can be stimulated in the context of programming courses [2].

Motivational processes are crucial to learning achievement across multiple subjects [3]. It is a driving force that triggers students to act towards learning, forming the basis for other critical psychological processes such as self-regulation of learning (SRL) [4]. On the other hand, unmotivated students are less likely to invest the necessary effort in their studies and are more susceptible to dropping out in adverse situations [1]. Thus, fostering and maintaining student motivation is critical to effective teaching and learning practices [5].

The study of motivational processes in education is commonly classified into self-motivational beliefs and goal orientation [6]. Self-motivational beliefs relate to an individual's confidence in their learning ability, while goal orientation refers to using strategies and methods to achieve specific learning goals [7]. Both these psychological elements have been associated with enhanced learning outcomes [7].

Over the years, researchers have been interested in investigating the motivational factors that affect the programming learning process. Existing evidence corroborates the relevance of self-efficacy, but the influence of other motivational aspects has less evidence [8].

This exploratory work aims to provide some evidence of the influence of several motivation-related variables on programming learning performance. We collected data from two computing student groups enrolled in the first programming course. The main distinction between the two groups is that one included students enrolled in a regular course, while the other included students enrolled in an after-work course. All the other variables (institution, teachers, syllabus, pedagogical approach, and assessment methods) were the same for both groups. With this setup, we also looked for differences in motivation between these two groups of students. Within the groups, we compared the motivation data in function of the students' previous programming experience and between those following the course for the first time and those that had failed in previous years.

Section II includes a brief literature review related to the themes of our study. Section III presents the instrument used and the motivational variables it measures. Section IV includes the characterisation of the study. In Section V, the most relevant results are presented and discussed. Section VI includes the conclusion of the paper.

II. Literature Review

Motivation, in the educational context, could be defined as a process in which students direct and sustain their efforts toward accomplishing educational tasks [8]. This process involves different psychological variables: persistence, pride, intrinsic and extrinsic interest, self-efficacy beliefs, and goal orientation. These elements drive students to engage, value, and accomplish their educational goals [4].

Students must regulate their motivation to achieve satisfactory motivational levels, which involves using different strategies [9]. Some examples include reducing distractions, evaluating self-consequences on concluding the task, goal setting, and increasing situational interest in the task [10]. Motivational regulation is studied under the umbrella of the self-regulation of learning theory.

SRL refers to intentionally using learning strategies to realise academic tasks [7]. This involves psychological processes of different natures, such as cognition, metacognition, motivation, emotion, and behaviour. A crucial part of SRL theory is the understanding that controlling these mental resources is critical to the learning process, including realising the motivational strategies discussed in the previous paragraph.

An increasing amount of research points to the relevance of SRL skills in the programming learning process [11]. The findings in the literature indicated that high-achievement students demonstrate better control over their regulation skills [12], and the lack of these abilities was associated with difficulties in completing programming exercises and lower programming performance [13]. However, a limitation of existing research on this theme is the increased focus on the cognitive and metacognitive aspects, leaving motivation and other areas with less evidence [14].

Despite the few studies investigating motivational regulation compared to other regulatory areas, the initial evidence points to its importance to the learning process [15]. A previous literature review summarising evidence regarding the association between SRL skills and programming learning performance found that most positive associations with course performance were from motivational variables [11->16]. Self-efficacy had the strongest correlation with course performance. This highlights the importance of students seeing themselves as capable of learning and confident in their abilities.

Other motivational variables were also discussed in the literature, pointing to their importance for learning. Among these, researchers argue that goal orientation is one of the most critical actions in education, influencing students' actions and their level of effort in self-regulation [17]. In the context of programming education, the findings corroborate the importance of goal setting. Lastly, beliefs about the course and how students perceive the usefulness of what they are studying are also essential components of the learning process [18].

III. MEASURING ACADEMIC MOTIVATION

Measuring academic motivation is a core aspect of SRL research. The Motivated Strategies for Learning Questionnaire (MSLQ) is one of the most used instruments [19]. It is divided into two main sections: motivation and learning strategies. The motivation section contains 31 items organised into three scales which in turn are organised into six subscales:

1. **The value Components scale** includes three subscales: a) Intrinsic Goal Orientation, b) Extrinsic Goal Orientation, and c) Task Value.
2. **The expectations Components scale** includes two subscales: d) Learning Control Beliefs, and e) Self-efficacy for Learning and Performance.
3. **The affective Components scale** includes a single subscale: f) Test Anxiety.

To better comprehend the results of our study, it is essential to understand what each subscale measures [19]:

1. **Intrinsic Goal Orientation** refers to a student's perception of why they are engaging in a learning task. This orientation concerns how much the student believes they are engaged in an activity for motives such as challenge, curiosity, or mastery. An intrinsic goal orientation toward academic work implies that student engagement is an end, not a means to an end.

2. **Extrinsic Goal Orientation** complements the previous scale by covering the degree to which the student considers themself engaged in an activity for reasons such as grades, reward, performance, peer evaluation, and competitiveness. Like the previous scale, the Extrinsic Goal Orientation scale refers to the general orientation for the course.

3. **Task Value** refers to the student's assessment of the assignment's interest, meaning, and usefulness. On the other hand, Goal Orientation concerns the reasons why the student participates in the task. A high value on the Task Value scale should lead to greater involvement in learning. In the MSLQ, this scale refers to students' perceptions of course material regarding interest, importance, and usefulness.

4. **Learning Control Beliefs** refer to students' beliefs that their effort to learn will result in positive outcomes. A high value on this scale suggests that the student believes the outcomes result from their effort rather than external factors, such as the teacher. If students believe their efforts make a difference in their learning, they will likely study strategically and effectively and adopt methodologies that lead to desired changes.

5. **Self-efficacy for Learning and Performance**, the items that make up this subscale, assess expectations of success and self-efficacy. Success expectations refer to performance expectations and relate specifically to task performance. Self-efficacy is a self-assessment of one's ability to master a task. Self-efficacy includes judgments about the individual's ability to perform a task and confidence in one's abilities to perform that same task.

a) **Test Anxiety** is negatively related to expectations and academic performance. This measure is divided into two parts: the cognitive component and the emotional component. The most significant sources of performance decline are cognitive and performance preoccupation. Training to use effective learning strategies and test-taking skills should help lower anxiety.

IV. CHARACTERIZATION OF THE STUDY

The following research questions guided this investigation: RQ1 - Which group of students exhibits the highest motivation levels, by scale and subscale; RQ2: Which group of students, on each scale or subscale, is the most motivated in terms of prior programming knowledge?; RQ3 - Which group of students on each scale or subscale is the most motivated, repeaters or non-repeaters?; RQ4: Is there a correlation between each group's scales, subscales, and final programming results?

The study focused on students enrolled in the course “Introduction to Programming” (IP) in the 2022/2023 academic year. This course belongs to the 1st year and 1st semester curricular plans of two Informatics Engineering degrees ministered at Coimbra Institute of Engineering of Polytechnic Institute of Coimbra: the degree in Informatics Engineering (LEI) and the degree in Informatics Engineering-Evening Classes (LEI-PL).

Both LEI and LEI-PL are 3-year degrees that aim to develop Informatics Engineers able to carry out their professional activity with a high degree of scientific and technical competence. They have the same curricular plan, the same teachers, the same type of assessments, and the same pedagogical methods. What differentiates them is the timetable: classes run from Monday to Friday, from 8:30 am to 8:00 pm in LEI and from 5:30 pm to 11:50 pm in LEI-PL. So, LEI-PL is more suitable for student workers due to its after-work class schedule.

The topics included in the IP course are usually taught in an introductory programming course, and the C language is used to teach the fundamental procedural programming concepts. The topics covered include fundamental concepts, like data types, operators and expressions, flow control mechanisms, standard input and output formatted data, data structures, functions, arrays, and string manipulation. Students solve programming problems while considering the different phases of writing a program (problem specification, analysis, algorithm, and implementation). This course has five contact hours per week, 2 hours of lectures with all the students, and 3 hours of lab classes in 13 groups of about 30 students each. In addition, teachers offer more than 6 hours per week to clarify students’ doubts during the semester.

The sample for the study included 98 volunteer students (82 from LEI and 16 from LEI-PL) from a total of 328 students that were enrolled in the IP course in the 2022/2023 academic year (274 in LEI and 54 in LEI-PL), as indicated in Table 1. Although one could expect students from LEI-PL to be older than those of LEI, an analysis of the information in Table 2 shows that this is only marginally true. However, as expected, most students from LEI-PL have professional and family responsibilities besides being students.

Students participating in the study were asked about their previous programming experience using any language. In LEI, 34 students declared to have previous programming experience, while 48 students declared the opposite. In LEI-PL, only four students declared to have previous experience, and 12 students had no previous experience.

The sample included students enrolled in IP (a Portuguese acronym for Introduction to Programming) for the first time and students who had failed in previous years and were repeating the subject. In the LEI group, 70 students were enrolled for the first time, and 12 were repeating. In LEI-PL, 13 students were first-timers, while three repeated the subject.

We wanted to determine students' initial motivation for their first programming subject. So, they were asked to answer the MSLQ questionnaire during the 4th week of classes because some questions involved the students' perception of programming, and, at that time, they would already have some knowledge. Students answered the online questionnaire on Google Forms during a face-to-face class.

Table 1. Distribution of students by degree.

	IP course		Sample	
	Number of students	***%***	***Number of students***	***%***
LEI	274	83.53%	82	83.67%
LEI-PL	54	16.47%	16	16.33%
Total	328	100%	98	100%

Table 2. Distribution of the ages

	Min	***Average***	***Max***	***Standard Deviation***
LEI	18	19,95	31	2,92
LEI-PL	18	22,31	33	5,31

V. Results Analysis

The reliability of the MSLQ instrument was calculated. It refers to the instrument’s internal consistency and was analysed using the Cronbach Alpha coefficient. The overall alpha for both groups (α =0,82 for LEI and α=0,79 for LEI-PL) suggests that the instrument is robust and presents reasonable/good internal consistency [20]. Also, these values compare well with the internal consistency reported in the original study where MSLQ was introduced [19].

Descriptive statistics were used to answer the research questions. The results obtained are shown in Table 3.

RQ1 - Which group of students exhibits the highest motivation levels, by scale and subscale, LEI or LEI-PL?

In general, the answers given by both groups of students were similar. Both groups scored higher on the Task Value subscale, showing that the learning task's interest, significance, and utility are significant to both groups.

The main difference between the groups was registered on the Learning Control Beliefs subscale, where the LEI-PL group scored higher. This means that this group was more convinced that their efforts to learn would be crucial and possibly the main factor for their success in learning.

The anxiety subscale yielded the lowest score in both groups. Test anxiety can harm academic performance and student expectations, but according to our results, this factor didn’t affect any groups strongly.

RQ2: Which group of students, on each scale or subscale, is the most motivated in terms of prior programming knowledge?

To answer this question, a similar analysis was made, separating, in each group, students who declared having previous programming experience from those who said they were contacting with programming for the first time. Naturally, the results are similar to those described concerning RQ1. Task Value received the higher scores in all subgroups, and Anxiety received the lowest scores.

In the LEI group, the averages across the several subscales were very similar in both subgroups, showing that students' motivational aspects were not influenced by their previous programming experience.

In LEI-PL, a difference was noted in the Learning Control Beliefs subscale, where the subgroup without programming experience scored higher, although the difference was not statistically significant. Maybe the previous experience of some students wasn't very positive, leading to a less optimistic view about their ability to control their learning

Table 3. Descriptive Statistics by group

	N		Average		Standard Deviation	
	LEI	*LEI-PL*	*LEI*	*LEI-PL*	*LEI*	*LEI-PL*
Intrinsic	82	16	5.1927	4.9250	.63902	1.04275
Extrinsic	82	16	5.3341	5.2125	.98045	1.20271
Task	82	16	5.8463	5.8375	.66243	1.10023
Value	**82**	**16**	**5.4476**	**5.3250**	**.53199**	**.734500**
L. C. Beliefs	82	16	5.2890	5.9125	.96328	.99188
Self-Efficacy	82	16	5.1768	5.3000	.86500	.80250
Expectations	**82**	**16**	**5.2146**	**5.6000**	**.79429**	**.77460**
Anxiety	82	16	4.5317	4.4000	1.27317	1.18884
Affective	**82**	**16**	**4.6146**	**4.4750**	**1.18583**	**1.31428**

RQ3 - Which group of students on each scale or subscale is the most motivated, repeaters or non-repeaters?

In this case, the two groups of students were divided considering being or not enrolled in the IP course for the first time.

Again, the results were similar, with Task Value receiving the highest scores and Anxiety the lowest. Notably, first-year LEI-PL students scored the Task Value even higher than the remaining subgroups, reinforcing this result.

RQ4: Is there a correlation between the various scales, subscales, and the final programming results in each of the two groups, LEI and LEI-PL?

Before answering this question directly, we looked for correlations between all the scales and subscales, obtaining the results in Table 4.

Although belonging to the same scale, the results for the Intrinsic and Extrinsic motivations subscales do not correlate in any of the groups (LEI and LEI-PL). This is reasonable, as individuals tend to have more intrinsic and extrinsic motivations, but not at similar levels.

Also worth noting is that Intrinsic motivation is highly correlated with Task Value. This subscale also strongly associates with Self-Efficacy and Learning Control Beliefs showing their importance. A strong inverse correlation between Self-Efficacy and Anxiety was verified in LEI, which seems natural.

The results concerning the association between the different scales and subscales and the final grades in the course are included in the column "Prog" in Table 4 (LEI group) and Table 5 (LEI-PL group).

In the case of LEI, the stronger correlation associates the grades and the Self-Efficacy subscale, reinforcing its importance for student success.

It is also worth noting that a weak inverse correlation was found between Extrinsic Motivation and grades, and the same happens between Anxiety and grades. If the results related to anxiety were expected, the inverse correlation with Extrinsic Motivation was less expected but reinforced the view that this type of motivation is less potent in leading students to make the necessary effort to learn than Intrinsic Motivation.

Self-efficacy refers to students' judgments of their talents, namely how confident they are in planning and carrying out the actions required to accomplish specific goals [21][22].

Self-efficacy plays a significant role in programming education as students experience various emotions throughout this process, often associated with negative feelings [23]. Therefore, having self-confidence in their abilities is an essential aspect of successfully learning to program.

Considering the importance of Self-Efficacy, we looked for its correlations with the remaining subscales. We found a positive correlation between Self-Efficacy and Intrinsic Motivation, Task Value, and Learning Control Beliefs. Also, these subscales are strongly correlated with each other. This indicates that individuals with higher self-efficacy tend to be more intrinsically motivated, perceive tasks as valuable, and have stronger beliefs in their abilities to control learning, resulting in higher expectations for success. The results align with previous research regarding the association between intrinsic motivation and task value with self-efficacy [24, 25]. Thus, these findings provide opportunities for educators to include in their pedagogical approaches elements that could stimulate their students' self-efficacy.

Anxiety has a robust negative correlation with self-efficacy, expectations, and affective (emotional) factors. This implies that individuals with higher anxiety levels may believe less in their capacity and experience more negative affective states. The results also indicate a negative association between anxiety and course grades. This emphasises the intricate relationship between various motivational variables and learning outcomes. Specifically, low self-efficacy can contribute to increased test anxiety, leading to lower grades.

Extrinsic motivation presented a negative correlation with grades, whereas intrinsic motivation had a weak positive association with them. Although the associations' intensity is weak, a tendency suggests that intrinsic motivation is more conducive to learning programming than extrinsic motivation. This finding is consistent with previous literature and highlights the importance of promoting students' understanding of the significance of coding for their personal growth [25].

7Table 4. Pearson's correlation analyses between scales, subscales, and final programming results - LEI

	Intrinsic	Extrinsic	Task	**Value**	L. C. Beliefs	Self-Efficacy	**Expectations**	Anxiety	**Affective**	Prog.
Intrinsic	1	.195	.450**	.708**	.369**	.320**	.394**	.103	.174	.079
Extrinsic	.195	1	.103	.726**	.282*	.102	.229*	.087	.042	**-.223***
Task	.450**	.103	1	.658**	.390**	.376**	.449**	-.140	.012	.192
Value	**.708****	**.726****	**.658****	**1**	**.486****	**.351****	**.489****	**.033**	**.099**	**-.017**
L. C. Beliefs	.369**	.282*	.390**	.486**	1	.490**	.881**	-.152	-.076	-.013
Self-Efficacy	.320**	.102	.376**	.351**	.490**	1	.843**	-.543**	-.360**	**.303****
Expectations	**.394****	**.229***	**.449****	**.489****	**.881****	**.843****	**1**	**-.390****	**-.244***	**.154**
Anxiety	.103	.087	-.140	.033	-.152	-.543**	-.390**	1	.829**	**-.243***
Affective	**.174**	**.042**	**.012**	**.099**	**-.076**	**-.360****	**-.244***	**.829****	**1**	**-.111**
Prog.	.079	-.223*	.192	-.017	-.013	.303**	.154	-.243*	-.111	1

**. The correlation is significant at 0.01 level (2-tailed). *. The correlation is significant at 0.05 level (2-tailed).

Table 5. Pearson's correlation analyses between scales, subscales, and final programming results – LEI-PL

	Intrinsic	Extrinsic	Task	**Value**	L. C. Beliefs	Self-Efficacy	**Expectations**	Anxiety	**Affective**	Prog.
Intrinsic	1	-.252	.746**	.727**	.633**	.457	.636**	.271	.378	.127
Extrinsic	-.252	1	-.087	.397	-.136	-.019	-.080	.458	.414	-.108
Task	.746**	-.087	1	.824**	.665**	.748**	.804**	.258	.325	.252
Value	**.727****	**.397**	**.824****	**1**	**.578***	**.596***	**.681****	**.521***	**.584***	**.149**
L. C. Beliefs	.633**	-.136	.665**	.578*	1	.506*	.898**	.335	.397	.355
Self-Efficacy	.457	-.019	.748**	.596*	.506*	1	.832**	-.017	.130	.439
Expectations	**.636****	**-.080**	**.804****	**.681****	**.898****	**.832****	**1**	**.224**	**.339**	**.455**
Anxiety	.271	.458	.258	.521*	.335	-.017	.224	1	.964**	.217
Affective	**.378**	**.414**	**.325**	**.584***	**.397**	**.130**	**.339**	**.964****	**1**	**.271**
Prog.	.127	-.108	.252	.149	.355	.439	.455	.217	.271	1

**. The correlation is significant at 0.01 level (2-tailed); *. The correlation is significant at 0.05 level (2-tailed)

Extrinsic motivation presented a negative correlation with grades, whereas intrinsic motivation had a weak positive association with them. Although the associations' intensity is weak, a tendency suggests that intrinsic motivation is more conducive to learning programming than extrinsic motivation. This finding is consistent with previous literature and highlights the importance of promoting students' understanding of the significance of coding for their personal growth [25].

Surprisingly, in the case of the LEI-PL group, it wasn't possible to find any positive or negative correlations between any of the subscales and the final grades (Table 5). The correlations between the subscales follow a pattern that is not significantly different from the case of the LEI group. An interesting difference is that Extrinsic Motivation does not correlate significantly with the other subscales, indicating that it may not strongly influence programming outcomes or other variables in this context.

Another interesting difference is that Anxiety shows a weaker positive correlation to Task Value in the case of LEI-PL, but Anxiety doesn't correlate with grades. This may happen due to the higher maturity of these students, who are used to managing anxiety in their daily life and have high levels of intrinsic motivation to pursue their learning objectives.

The LEI-PL group results may have been affected by the small number of students that group included. This may explain the absence of correlation between their grades and any of the motivational variables observed.

VI. CONCLUSIONS

The present work studied several motivational aspects of two groups of programming students. The motivation section of the MSLQ instrument was used.

The first research question aimed to verify the students' motivational levels and identify possible differences. It was found that students from both groups showed high motivation and were mainly driven by the value they attributed to the tasks, believing that their effort to learn would lead to positive results. LEI group scored higher on Learning Control Beliefs, which suggests that these students are likely to study strategically and effectively to achieve their goals. In contrast, both groups had lower scores on the Anxiety subscale and the corresponding Affective scale, meaning that these aspects may not negatively affect their academic performance.

The second research question tried to find differences between students with some previous programming experience and those without. No significant differences were found in this context. It was interesting to note that students without previous programming experience in the LEI-PL group scored higher on Learning Control Beliefs, possibly due to their hope that they could learn to program without too many difficulties.

The third research question was similar to the second, distinguishing between students who had failed the course in the past and those who were enrolled for the first time. Although some interesting values were found, it was not possible to establish statistically significant differences between those subgroups.

Finally, the fourth research question examined correlations between the various subscales and the final programming results. Although there is a similar trend of correlations between several subscales in both groups, things are different regarding correlations between the various subscales and grades. Self-efficacy and grades strongly correlate in LEI but not in the LEI-PL group. This can be attributed to the group characteristics, as it primarily includes students who often have established family and professional commitments. These factors may pose constraints that prevent them from ultimately achieving their objectives.

Carrying out this study allowed us to identify and confirm factors that influence students' results. This knowledge may help influence pedagogical approaches to help students achieve their learning objectives.

Acknowledgment

This study was conducted with the agreement of the Coimbra Institute of Engineering presidency and with the consent of the students who collaborated. The authors would like to thank all students that participated in the study.

References

[1] L. Peck, J. E. Stefaniak, and S. J. Shah, "The correlation of self-regulation and motivation with retention and attrition in distance education." The Quarterly Review of Distance Education, vol. 19, pp. 1–15, 2018.

[2] A. Gomes, M. J. Marcelino, K. Wei, C. T. Lam, and A. J. Mendes, "Student motivation towards learning to program", in Proceedings of the 48th Annual Frontiers in Education (FIE'18) Conference, 2018, San Jose, CA, USA.

[3] C. Sansone, T. Fraughton, J. L. Zachary, J. Butner, and C. Heiner, "Self-regulation of motivation when learning online: the importance of who, why and how," Educational Technology Research and Development, vol. 59, no. 2, pp. 199–212, 2011.

[4] B. J. Zimmerman, "Becoming a self-regulated learner: An overview," Theory Into Practice, vol. 41, no. 2, pp. 64–70, 2002.

[5] A. Gomes, and A. J. Mendes, "A teacher's view about introductory programming teaching and learning difficulties, strategies and motivations," in Proceedings of 44th ASEE/IEEE Frontiers in Education Conference (FIE'14). Sevilla, Spain.

[6] J. Hilpert, J. Stempien, V. D. Hoeven, K. Kraft, and J. Husman, "Evidence for the latent factor structure of the mslq: A new conceptualization of an established questionnaire," SAGE Open, vol. 3, no. 4, 2013.

[7] B. Zimmerman and D. Schunk, Self-Regulated Learning and Performance. Routledge, 2011, pp. 15–26.

[8] A. Berhenke, "Motivation, self-regulation, and learning in preschool," Tech. Rep., 2013.

[9] C. Grunschel, M. Schwinger, R. Steinmayr, and S. Fries, "Effects of using motivational regulation strategies on students' academic procrastination, academic performance, and well-being," Learning and Individual Differences, vol. 49, pp. 162–170, 7 2016.

[10] C. Wolters, "The relation between high school students' motivational regulation and their use of learning strategies, effort, and classroom performance," Learning and Individual Differences, vol. 11, no. 3, pp. 281–299, 1 1999.

[11] L. Silva, A. Mendes, A. Gomes, and G. Fortes, "Fostering regulatory processes using computational scaffolding", International Journal of Computer-Supported Collaborative Learning, 2023, pp. 67-100.

[12] K. Arakawa, Q. Hao, T. Greer, L. Ding, C. Hundhausen, and A. Peterson, "In situ identification of student self-regulated learning struggles in programming assignments," in Proceedings of the 52nd ACM Technical Symposium on Computer Science Education. ACM, 3 2021, pp. 467–473.

[13] K. E. Falkner, C. Szabo, R. Vivian, and N. J. G. Falkner, "Evolution of software development strategies," 2015 IEEE/ACM 37th IEEE International Conference on Software Engineering, vol. 2, pp. 243–252, 2015.

[14] D. Loksa, L. Margulieux, B. Becker, M. Craig, P. Denny, R. Pettit, and J. Prather, "Metacognition and self-regulation in programming education: Theories and exemplars of use," ACM Transactions on Computing Education, vol. 22, no. 4, pp. 1–31, 12 2022.

[15] E. Aivaloglou and F. Hermans, "Early programming education and career orientation," in Proceedings of the 50th ACM Technical Symposium on Computer Science Education. ACM, 2 2019, pp. 679–685.

[16] L. Silva, A. Mendes, A. Gomes, G. Lam, and C. Chan, "Exploring the association between self-regulation of learning and programming learning: A multinational investigation" in IEEE Fronties in Education Conference, 2021, pp. 1-8.

[17] D. H. Schunk, "Self-regulation through goal setting. eric/cass digest." 2001.

[18] K. Nelson, D. Shell, J. Husman, E. Fishman, and L.-K. Soh, "Motivational and self-regulated learning profiles of students taking a foundational engineering course," Journal of Engineering Education, vol. 104, no. 1, pp. 74–100, 2015.

[19] P. R. Pintrich et al., "A manual for the use of the motivated strategies for learning questionnaire (mslq)." 1991.

[20] M. Tavakol and R. Dennick, "Making sense of Cronbach's alpha," International Journal of medical education, vol. 2, p. 53, 2011.

[21] P. Rosário, J. Núñez, and J. González-Pienda, "Comprometer-se com o estudar na universidade: cartas do Gervásio ao seu umbigo," Porto: Almedina.

[22] J. A. Greene, J. Robertson, and L-J. C. Costa, (2011). Assessing self-regulated learning using think-aloud protocols. In B. J. Zimmerman & D. H. Schunk (Eds.), Handbook of self-regulation of learning and performance (pp. 313–328). New York, NY: Routledge.

[23] M. Coto, S. Mora, B. Grass, and J. Murillo-Morera, "Emotions and programming learning: systematic mapping," Computer Science Education, vol. 32, no 1, pp. 30-65, 2022.

[24] E. Aivaloglou, and F. Hermans, "Early programming education and career orientation: the effects of gender, self-efficacy, motivation and stereotypes," in Proceedings of the 50th ACM technical symposium on computer science education, 2019, pp. 679-685.

[25] Ü Avcı, "A predictive analysis of learning motivation and reflective thinking skills on computer programming achievement," *Computer Applications in Engineering Education*, vol. *30, no* 4, pp. 1102-1116, 2022.

TEACH THE IMPORTANCE OF LOGIC (PROGRAMMING) IN COMPUTER SCIENCE AND WHY IT IS IMPORTANT.

Joaquín Arias
CETINIA, Universidad Rey Juan Carlos
Madrid, Spain
joaquin.arias@urjc.es

***Abstract*—This paper supports the importance of teaching logic (and logic programming) in computer science degrees and discusses several proposals that can be included in current curricula without the need to adapt the academic guides. In addition, some practical examples are described and the tools used for their subsequent application are related.**

***Index Terms*—logic, logic programming, computer science, modeling, thinking, final degree project**

I. INTRODUCTION

Logic is the science that studies the formal validity of reasoning. Through the formalization of language and its basic rules, it provides the necessary tools to rigorously solve problems that have their origins and applications in all areas of science [2], [8], [12], and especially in computer science.

It is, therefore, natural that mathematical and computational logic are basic subjects in most university degrees related to computer science [1], [6]. Their study often has the difficult task of compensating for possible shortcomings in the students' previous training. In addition, it serves to improve the three basic skills of reading, mathematics and science (assessed in the Spanish context through the PISA 2018 report (available at https://www.oecd.org/pisa) and the ability to reason analytically and critically. One of the main didactic objectives of logic subjects is "the ability to acquire, obtain, formalize and represent human knowledge in a computable form for the resolution of problems by means of a computer system in any field of application, particularly those related to aspects of computation, perception and performance in intelligent environments".

The content of this article is related to the teaching experience acquired teaching in different courses and in different degrees related to computer science at the Escuela Te´cnica Superior de Informa´tica of the Universidad Rey Juan Carlos.

- Logic course in first grade: from our point of view, a main objective of Logic is to introduce some systems of formal proof. For most students it is not immediate to justify correctly the validity of a reasoning or the resolution of a concrete problem and they need a broad introduction to formal languages to learn this skill.

 The deductive methods of mathematical logic are at the basis of the automatic proof of theorems. It is a matter of finding the most efficient proof systems for implementation on a computer. Students would have to apply proof methods in more advanced courses of computer science degrees, for example, in the Declarative Programming course [17], which traditionally includes logic programming and functional programming.

- Declarative Programming course in the second year: This course does not require adaptation to incorporate activities or content related to logic, although sometimes the teaching of logic programming is sacrificed in favor of functional programming due to its greater prevalence as a programming language in the industry.
- Third and fourth year subjects: In recent years we have observed that it is not easy to get university students to understand the importance of logic and its applications to programming. In fact, due to lack of references, they do not value the learning acquired in the first course. Similarly, we have detected deficiencies in the writing of technical reports, in the analysis or synthesis of informa- tion and in preparing and giving presentations.
- Final Degree Project: It is undoubtedly the last opportunity for students to incorporate issues related to logic, so important in the professional development of an engineer: motivation of the importance of the problem to be solved, modeling of problems and definition of objectives, analysis of existing solutions, justification of the proposal, synthesis of the results obtained in the evaluation of the proposal and conclusions based on them.

In this article we propose a series of activities to be applied in the subject of Logic, in some subjects of the last courses and in the statement of work for the Final Degree Project. We have decided not to propose activities in the Declarative Programming subject because on the occasion of the 50th anniversary of Prolog there are a number of initiatives aimed at providing teaching materials [16] and designing teaching guides [7], [10], [19] to improve the teaching of logic programming at university.

The aim of these activities is to make students aware of the importance of logic in the field of computer science, not only as a fundamental basis of computer science but also as a skill set for professional growth, in whatever specialization.

In Section II we describe the specific objectives for the formative stage in the degree, the theoretical context of each activity and provide links to the tools or methodologies used.

As part of the Scaffolding Online University Learning: Support Systems project (2022-1-IT02-KA220-HED-000090206 SOULSS), founded by European Commission-Erasmus Agency (2022-2025).

In Section III we provide evidence of the different experiences implemented in the 2021/2022 and 2022/2023 academic years. Finally, Section V presents the conclusions and future work.

II. Linking logic with programming

In this section we offer some suggestions for incorporating the fundamentals of logic and its importance in the devel- opment of computing in different subjects and with different perspectives or objectives. As mentioned above, we offer suggestions for the Logic course (Section II-A), for subjects of the last courses of the degree (Section II-B) and for the Final Degree Project (Section II-C).

A. Logic in the first course

The importance of Logic is well known in: artificial intelligence (logic formalizes knowledge and inference manipulates it); Expert Systems and logic programming for knowledge representation; natural language recognition and processing; semantic description and program verification; automatic proof of theorems and problems; and symbolic equation solving. However, it is not easy for a first-year student in a computer science degree to understand this linkage, partly because he or she does not know what most of these terms consist of.

Traditionally, because of its more intuitive formulation, Gentzen's method of Natural Deduction is presented in logic courses [2], [8], [9]. In the Natural Deduction system there are no axioms and inference rules can be easily interpreted as predefined functions with a concrete API (Application Programming Interface). Derived rules are then subroutines that can be defined for reuse in various demonstrations without having to repeat a particular demonstration pattern, e.g. the derived rule ModusTollens (see pages 51-52 of Tema 2 in [2]). To motivate students we propose the use of DeduccionNatu- ral.pl [2], a program that we have implemented in Prolog (see fig. 1 and that can be easily run in the Ciao Prolog Playground, https://tinyurl.com/deduccionnatural23. The main function of DeduccionNatural.pl is to automatically check the correctness of proofs made using Gentzen's method of Natural Deduction. To use or contribute to the improvement of DeduccionNatural.pl you can consult:

- Code repository on GitHub.[1]
- The user manual, 2022. Published on BURJC [18]. https: //burjcdigital.urjc.es/handle/10115/20168
- Tutorial videos on YouTube,[2] and TV-URJC.[3]

B. Final years of the degree

In the last courses of computer science degrees (and similar) we find several subjects oriented to show students past and present development techniques used in the industry and that it is important for them to know (at least their existence). Given the large number of techniques and the limited time available in these courses, an important decision has to be made: to devote more time to a particular technique, so that students acquire some practical exposure, or to distribute the time among the different techniques without being able to go sufficiently deep.

We favor the first option but with two important nuances:

- The students have the possibility to choose, in groups of 3 to 5 students, the technique they want to study in depth. Each group presents the technique to be developed to the teacher and the teacher guides them by posing questions and lines of research related to that technique.
- The work is evaluated by the delivery of a presentation and a report (which includes a critical analysis of the work presented by their classmates).

Additionally, in the selection of the topics to be developed, they are encouraged to use available tools with use cases related to the group's interests and whenever possible to find out if there are research articles or news in which they can identify lines of research related to this technique.

At this point, it is important to remind students of the historical context in which we found ourselves with regard to logic and computer science by marking three key dates:

- 1931: Gö̈del presents the first incompleteness theorem: No formal mathematical theory capable of describ- ing the natural numbers and arithmetic with suffi- cient expressiveness is both consistent and complete.

  that is, if the axioms of a theory do not contradict each other (consistency), then there are statements that can NOT be proved or disproved from them (completeness). And the second incompleteness theorem: One of the undecidable sentences of a theory is that which affirms the consistency of the theory. these theorems represent the turning point in terms of the expectations of logic.
- In 1920 Hilbert had raised the problem of "the axiom- atization of mathematics" and Go¨del's theorems show that it is not possible. This had a great impact on the expectations raised by logic when, in the 4th century B.C., Aristotle proposed to formalize human reasoning.
- Later, in 1936, independently, Church solved the "Entscheidungsproblem" (developing the Lambda Calcu- lus) and Turing posed the "Halting problem" (developing the Turing machine). Analyzed independently, they are important, but more relevant is their consequence:

  Logic and Computation are equivalent (Church-Turing thesis): Determining the halting problem reduces to proving in first-order logic the formula that expresses the existence of an output from the application of a series of instructions.

There are many references to this historical context, but I would recommend watching the video "Las Matema´ticas tienen una Terrible Falla" (available at https://youtu.be/ RRg38oNQ9vk)). It is clear that these results have two imme- diate consequences: (i) no matter how much progress we make in the development of computation there are activities that we

[1]GitHub: https://github.com/Xuaco/DeduccionNatural.

[2]YouTube tutorials: https://youtu.be/gpWFFFUTHX0, https://youtu.be/ G7i55ub4dW0, and https://youtu.be/K1clmokaOsY.

[3]Channel at TV-URJC https://tv.urjc.es/series/63225436749db0424d5eca57.

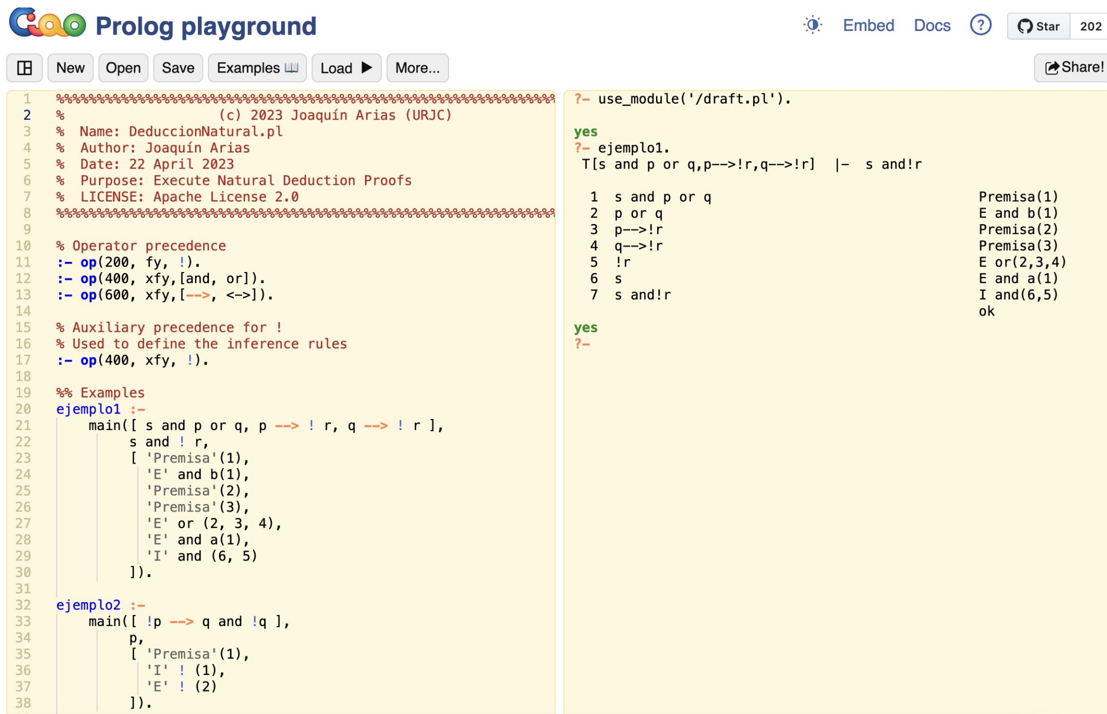


Fig. 1. Screenshot with the execution of `DeduccionNatural.pl` .

cannot automate and (ii) computer scientists will always have work to do because our work is one of these activities.

This activity intends to awaken students' critical thinking, expose them to the task of searching for information on a topic not only in textbooks but also in research articles, write a short report following writing standards similar to those of the Final Degree Projects, give and attend presentations on topics new to them and, finally, awaken in them an interest in research.

This last objective does not appear in any indicator of competencies to be acquired by students but it is of vital importance if we want to maintain the research activity of universities –by training students for the industry without training for research activity we strangle research groups, including those within companies.

C. *Final Degree Project*

Incorporating aspects of logic or logic programming is a very particular task of the tutor and the student when agreeing on the statement and scope of the final thesis. However, in many cases the student is working in a company and his/her aptitude for the development of the final project is more engineering (solving a problem) than research (analysis of existing solutions or lines of research and development of a proposal based on this analysis).

In order to, as far as possible, attract students to the world of research, we propose that the teacher offers topics to be developed where the student has to adapt use cases implemented with prototypes developed in (their own) research groups.

To motivate students we propose different actions (ordered according to their economic impact and difficulty to manage them from the bureaucratic point of view):

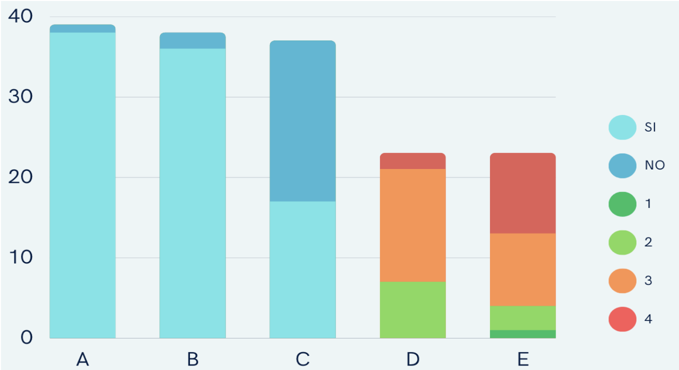
- Provide the laboratory with computer equipment and a place for students to work and interact with the researchers of the research group (doctoral students, postdoctoral students, among others).
- Submit articles to national congresses so that, if accepted, the registration and travel expenses to present the work will be paid by the university.
- Offer them a 15-day stay in a foreign research center to learn about other lines of research related to the topic of the Final Degree Project.
- Hire them as assistants for research projects.

III. Examples and evaluation

In this section we show some examples of the application of these ideas and the results obtained. Although the sample is really small, the results seem to us significant enough to validate the convenience of applying these suggestions. We follow the same structure of the previous section: first we show experiences in the subject of Logic, then in subjects of the last courses and finally in the development of final projects.

A. *Using DeduccionNatural.pl in first grade Logic*

In order to evaluate our didactic proposal for the subject of Logic, we have implemented the use of DeduccionNatural.pl during the development of practical activities in two groups of students belonging to two different courses. For one of them, the use of the tool was mandatory, while for the other its use



Please answer Yes or No:
A: Have you used the program?
B: Have you used the program to check manifestations?
C: Have you used the program as a study tool?
Rate from 1 (bad) to 4 (very good): D: Ease of use.
E: Usefulness for learning Natural Deduction.

Fig. 2. Results of the DeduccionNatural.pl satisfaction survey on the Artificial Intelligence degree.

was voluntary. The results of this experience were presented at the XXIX Jornadas de Ensen˜anza Universitaria de Informa´tica (JENUI'23) [5].

Figure 2 shows the results of the survey of the 40 students in the Artificial Intelligence degree program. The number of responses to each question decreases because when for questions *A*, *B* or *C* they answered *no*, they could stop filling out the survey.

While the vast majority claim to have used the tool for practice, question *B*, the same is not true when asked if they have used it as a learning tool, question *C*. It is important to note that the groups were of three students, therefore, not all of them had to have used DeduccionNatural.pl when doing the practice –the results observed in the survey coincide with the perception we had during the development of the practices, since all the students attended class and worked solidarily in all the exercises.

On the other hand, with respect to the question on ease of use, question *D*, there is a certain neutrality in the ratings. Note that we have used the scale 1..4 to avoid students choosing an intermediate rating (as would be the case if we used the Likert scale, 1..5). From our classroom experience, we interpret that the tool has been easier to use for students with programming experience and less so for those without.

Finally, the answers to the question *E*, on usefulness for learning natural deduction (the main objective of this tool), indicate that the tool has been useful for most of them. In view of these results, we conclude that the design of the interface needs to be improved, but that the objective of facilitating the learning of natural deduction has been achieved.

B. Practice in the secure development methodology course

The secure development methodology course is part of the third year of the Cybersecurity degree at the Universidad Rey Juan Carlos and this practice corresponds to the 2021/2022 academic year. The statement of the practice was very brief, it was indicated:

- Objective: The objective of this practice is for the stu- dent to become familiar with the terminology used in secure software development and to put into practice the concepts related to secure development cycles and methodologies, trusted operating systems and/or good development practices.
- Submission instructions.
- Choice of the research topic: Each group will propose a title and a topic related to the subject that must be approved by the professor. During the development of the research, the group may propose an update of the title in a justified manner.
- Details of deliverables (presentation and report): the report is prepared (preferably) using LATEX and special attention is given to the inclusion of references.

Due to lack of space, this article does not include the statement or show the results of the experience. The following link (http://platon.etsii.urjc.es/~jarias/mmm/MDS/) provides the statement and the papers presented by the students. Among all the works I want to highlight the one done by group G entitled "How to detect metamorphic malware in dependencies" because these students asked me for references on the application of abstract interpretation in Cybersecurity and from a couple of references they contacted Roberto Giacobazzi, an outstanding Italian researcher, author of more than 100 publications in international journals and congresses and involved in national (Italian) and international (European) research projects in the field of static analysis of programs. In general the result of the experience was exceptional, most of the groups contacted professionals related to the subject (cho- sen by themselves) and in many cases they dared with critical approaches (perhaps motivated by their professor) but always providing data and arguments to justify such approaches.

C. Final Degree Projects

Although this subject is the last opportunity for students to complete their training, it is sometimes considered (motivated by its autonomous work component) as a test in which

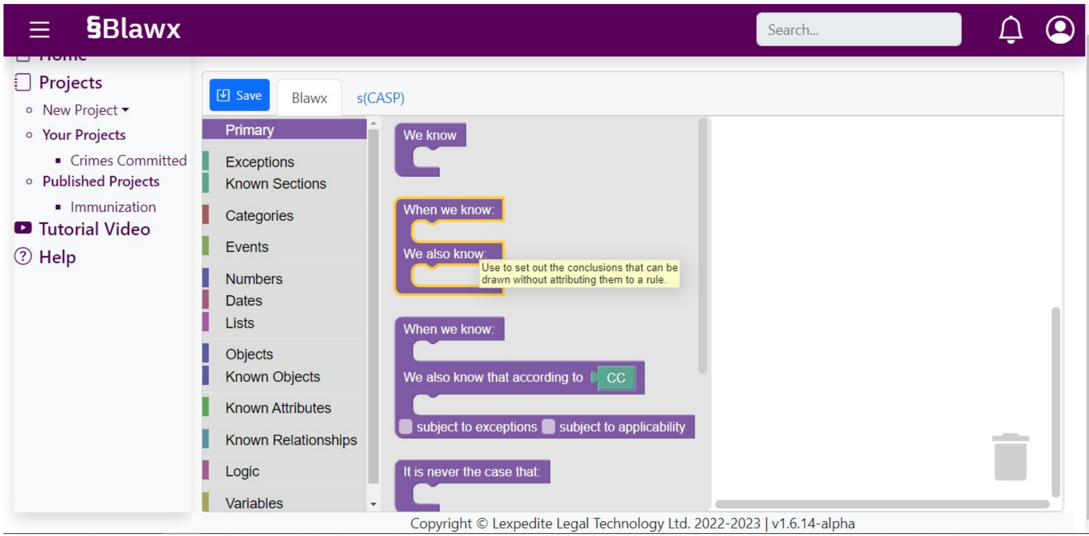


Fig. 3. Screenshot of the Blawx web interface.

the student must demonstrate that he/she has acquired the necessary competences to obtain the degree.

In relation to the methodologies to be implemented in the development of the final projects there are many proposals but in this article we want to focus on a specific aspect, already mentioned in the previous section. Our proposal aims to initiate the student in the field of research not only by proposing work related to ongoing lines of research but also through the development of such work.

In the context of final theses I would like to highlight two. The first one is "MMDect: Metamorphic Malware Detection using Logic Programming" by Luciana (available at http://platon.etsii.urjc.es/~jarias/tfg/23-Luciana.pdf). This work can be considered a continuation of the work developed by Group G in the Secure Development Methodology course described in the previous section. Luciana is one of the members of the group and she wanted to continue with the theme of the work by extending a work developed by Roberto Giacobazzi:

Malware has become a major concern as the tech- niques used by the malicious actors improve on an ongoing basis, e.g., by using metamorphic malware, which modifies its own code to a semantic equiv- alent code. In parallel, anti-malware technologies have advanced, resulting in different techniques for detecting or classifying malicious programs. Even then, each technique has its limitations. For example, classic static analysis is very vulnerable to code changes, dynamic analysis requires the code to be executed in a specific environment and AI behavioral technology reports many false positives, and it is easy to fool once its classification method has been analyzed. In this work, we improve on static analy- sis approaches by including a metamorphic rules-based technique, which transforms lines of code into semantic equivalents patterns (reproducing what metamorphic malware does). The resulting tool, MDDect can detect variations of malware (following certain metamorphic rules) based on given signatures (patterns of code) that identify malicious behaviors or subroutines. Initially, we implemented MDDect under Python, but to facilitate the extension of the tool with new rules we re-implemented it under Prolog. To validate MDDect we use 4 examples, a (real) use case, and randomly generated programs including from zero to three signatures between harmless code blocks. In the use case, we assume the existence of a signature of a program written in Intel assembly that compromises the confidentiality of the host by printing a file to stdout with potentially elevated privileges.

The second project is "Modeling and estimation of criminal sentences using Logic Programming" by Elena (available at http://platon.etsii.urjc.es/~jarias/tfg/23-Elena.pdf). In this case the student has studied a double degree in Criminology and Computer Science and a colleague from the research group told me about the possibility of proposing her a work related to my line of research. As a result of this project we have been able to validate s(LAW) [4], a tool we are developing to model legal texts, and experiment with Blawx, an online interface developed by Jason Morris (available at https://www.blawx.com), which facilitates the translation of legal texts thanks to s(CASP) [3], the logical reasoner that s(LAW) and Blawx use as a backend (Fig. 3 shows the Blawx online interface implemented using the Google Blockly library):

In Spain, the legal system continues to be an area where the use of more traditional methods is prior- itized over the use of new technologies. Although there are several valid reasons why this is still the case, we cannot deny the intrusion of the new artificial intelligences in environments where they had never had a place before, so it would not be unreasonable to think of a future where these two worlds are united. In this project we have searched for a way to remotely approach that future, developing a system to obtain an estimate of the sentence as a result of the commission of a series of crimes. Thus, we make use of logic programming to model and justify the legal bases that will lead to a final minimum and maximum penalty, focusing also on obtaining a natural language reasoning that makes up the final result. Specifically, the main part of the project has been implemented thanks to the s(CASP) system. Moreover, we wanted to show another innovative way to model the law through the Blawx application. Both tools will be explained in detail throughout this paper. The reason why we have sought to express the final result in natural language was to try to make the tool also (and mainly) available to the average person who has no knowledge in computer science; we seek to offer in the future a web tool that can help both students in the field of law and ordinary people with simple curiosity; and maybe, if the tool professionalized, it would help justice workers to obtain a rough estimate of the penalty.

These projects show that the proposed approach gives results and encourages us to continue on this path.

IV. Related work

Evidently, there are several works showing the similari- ties between the proofs in natural deduction and computer science [14], and tools related with natural deduction (with various features and complexity) have been developed. For example: Taut-Logic (https://www.taut-logic.com), Fitch (http://logic.stanford.edu/logica), the “Asistente para la Deducción Natural” (ADN), developed at the University of Alicante [13], the “Lógica Simbólica Deductiva” (LSD), developed at the University of Girona [11], and others, such as those described in [15]. However, these tools do not emphasize the similarities between natural deduction and programming, and, moreover, although most of them are open source, it is not easy to access their source code (if they are operational, which not all of them are) to adapt them.

Additionally, there are proposals for formalizing proofs in natural deduction and examples of logical games:

- Pepa Hernández (UPM), proposes the inference rules and the indentation-based format for the demonstrations implemented in DeduccionNatural.pl.
- Jose´ A. Alonso Jiménez (US), has a multitude of works on Logic, from notes to introductory exercises to Prolog.
- José Morales (UPM), uses theorem provers, e.g., to prove the logic problem of the *wolf, sheep and lettuce* with Z3.

V. Conclusions and future work

As already mentioned, the examples and evaluations pre- sented in this article do not allow us to draw conclusions due to the small sample population. However, the success stories obtained in only two years allow us to be optimistic and we believe it is necessary to present these suggestions to the educational community in order to extend these results.

We believe that the teaching of logic in all computer science courses is essential to provide students with critical thinking, the ability to reason, analyze and synthesize information, and eventually awaken in them an interest in research in fields such as program verification, symbolic artificial intelligence, abstract interpretation, cryptography, and formal methods.

As lines of future development we focus on providing the research group with computer equipment for undergraduate students (15” MacBook Air laptops), work spaces (with er- gonomic chairs with headrests) and we have applied for a teaching innovation project to cover the registration fees for conferences where students can present their Final Degree Projects (travel will be covered by research projects or grants).

References

[1] ANECA. Libro Blanco del Titulo de Grado en Ingeniería Informática. Proyecto EICE, 2005.
[2] Joaquín Arias. *Lógica: desde Aristóteles hasta Prolog*. Servicio de Publicaciones URJC, 2022. http://hdl.handle.net/10115/20014.
[3] Joaquín Arias, Manuel Carro, Elmer Salazar, Kyle Marple, and Gopal Gupta. Constraint Answer Set Programming without Grounding. *Theory and Practice of Logic Programming*, 18(3-4):337–354, 2018.
[4] Joaquín Arias, Mar Moreno-Rebato, Jose A. Rodriguez-García, and Sascha Ossowski. Modeling Administrative Discretion Using Goal-Directed Answer Set Programming. In *CAEPIA 20/21*, volume 12882 of *LNCS*, pages 258–267. Springer, 2021.
[5] Joaquín Arias, Iván Ramírez, and Alessandra Gallinari. DeduccionNatural.pl: herramienta escrita en Prolog para el aprendizaje de la asignatura de Lo´gica. *JENUI 2023*, pages 129–136, 2023.
[6] Association for Computing Machinery (ACM) and IEEE. Computing Curricula 2020: Paradigms for Global Computing Education, 2020.
[7] Laura A Cecchi, Jorge P Rodríguez, and Verónica Dahl. Logic programming at elementary school: Why, what and how should we teach logic programming to children? In *Prolog: The Next 50 Years*, pages 131–143. Springer, 2023.
[8] Alessandra Gallinari. *Apuntes y problemas de la lógica matemática*. Dykinson, Madrid, 2009.
[9] Gerhard Gentzen. Untersuchungen u¨ber das logische schließen. I. *Mathematische Zeitschrift*, 35:176–210, 1935.
[10] Manuel V. Hermenegildo, Jose F. Morales, and Pedro Lopez-Garcia. Some thoughts on how to teach prolog. In *Prolog: The Next 50 Years*, pages 107–123. Springer, 2023.
[11] Josep Humet. LSD, una herramienta didáctica para el aprendizaje de la lógica. *JENUI 2001*, pages 482–485, 2001.
[12] Jose Emilio Labra Gayo. ¿Hay Lógica en la situación actual de las titulaciones informáticas? In *JENUI 2004*, pages 227–234, 2004.
[13] Faraón Llorens Largo and Sergio Mira Cabrera. Herramienta para la enseñanza de la deducción Natural. In *JENUI 2000*, pages 496–502, 2000.
[14] Faraón Llorens Largo, Rosana Satorre Cuerda, Francisco Escolano, and Pilar Arques Corrales. Deduccio´n natural versus computacio´n. *JENUI 1999*, pages 259–265, 1999.
[15] Petr Manas. CLPractice 2.0. Tools for Learning: Computation and Logic. *University of Edinburgh*, 2021. https://shorturl.at/boW47.
[16] Jose F Morales, Salvador Abreu, Daniela Ferreiro, and Manuel V Hermenegildo. Teaching prolog with active logic documents. In *Prolog: The Next 50 Years*, pages 171–183. Springer, 2023.
[17] Ana Pradera and Juan M. Serrano. *Programacio´n Declarativa: presenta- ciones*. BURJC-Digital, 2022. https://hdl.handle.net/10115/20609.
[18] Iván Ramírez and Joaquín Arias. *DeduccionNatural.pl, Manual*. BURJC-Digital, 2022. http://hdl.handle.net/10115/20168.
[19] Veneta Tabakova-Komsalova, Stanimir Stoyanov, Asya Stoyanova-Doycheva, and Lyubka Doukovska. Prolog education in selected secondary schools in bulgaria. In *Prolog: The Next 50 Years*, pages 144–153. Springer, 2023.

APPLICATION FOR THE ACADEMIC MANAGEMENT OF SUPERVISED CLINICAL PRACTICUM IN *NURSING DEGREE*

Rosa M. Carro
Computer Science Department
Universidad Autónoma de Madrid
Madrid, Spain
rosa.carro@uam.es

Pablo Izaguirre
Computer Science Department
Universidad Autónoma de Madrid
Madrid, Spain
pablo.izaguirre@estudiante.uam.es

María Isabel Guzmán Almagro
Nursing Department
Universidad Autónoma de Madrid
Madrid, Spain
isabel.guzman@uam.es

Ana Isabel Parro-Moreno
Nursing Department
Universidad Autónoma de Madrid
Madrid, Spain
anaisabel.parro@uam.es

***Abstract*—This work focuses on the development of a web application to facilitate the management and evaluation of the practicum training in Nursing Degree at Universidad Autónoma de Madrid. The aim is to streamline processes such as the evaluation of students and the monitoring of their activity at the hospital, and to serve as a support tool for the students in Nursing Degree, all this using efficient scalable technologies and providing a modern and attractive interface. The result is an application that improves the efficiency and experience of the different users involved in the practicum training process (teachers at the university, tutors at the hospitals and students), providing tangible benefits according to a conducted evaluation by an end users group.**

Keywords—Web application, clinical nursing practice, assessment improvement.

I. INTRODUCTION

Practical clinical learning is a fundamental aspect of the nursing curriculum. In Spain, in consonance with the framework established by the European Higher Education Area (EHEA), students are required to accumulate a total of 240 European Credits Transfer System (ECTS) credits over four academic years in order to earn a Degree in Nursing. Of these, approximately 90 ECTS credits correspond to pre-professional placements in real clinical settings over the course of 3 years.

During clinical placements, students are expected to acquire a range of competencies essential to providing effective and safe nursing care. They do their clinical training at several health centers and hospitals. The most important are La Paz, Puerta de Hierro Majadahonda, La Princesa and Niño Jesús. There is also a Family Medicine and Primary Care Unit that complements the outpatient element of students' clinical training.

One of the tasks to be carried out by the university lecturers responsible for clinical placements is to grade their assigned students. In order to award these grades, they base on the information provided by the tutors, professionals who host the students during their hospital stay. At the end of the clinical training period, the tutors normally fill in an evaluation questionnaire for each student, which must include the assessment of the acquired competences.

This research was co-funded by the Spanish Ministry of Science and Innovation, project IndiGo! number PID2019-105951RB-I00; the Structural Funds FSE and FEDER, project e-Madrid-CM number S2018/TCS-4307; and the National Conference of Deans of Nursing, project SIE2-P number PI-03CNDE2019.

This is not an easy task for these professionals, who, in their day-to-day work, with the hustle and bustle of hospital activity, do not usually record the competences acquired by the students in the different practical activities they perform. Therefore, it is complex to remember all this information afterwards. This is compounded by the fact that students are often with different professionals during a placement period, which makes it even more challenging for tutors to collect all the information on the student's performance.

During clinical placements, student attendance must also be recorded: the start and end time should be recorded, as there is a minimum number of hours to be spent at the hospital. At present, there is no simple and effective way to monitor the student's attendance, since signature sheets (documents recording the presence of each student) can be easily misplaced or manipulated. For this reason, students are sometimes directly trusted to attend the hospital when it is their turn.

In this context, a group of lecturers from the Department of Nursing at Universidad Autónoma de Madrid (UAM) is working on improving the competency assessment questionnaire used to evaluate students, with the aim of proposing more exhaustive questionnaires that will improve student monitoring and evaluation. During the development of this set of questionnaires, this work team considered the possibility of providing digital support for this new assessment format.

In healthcare context, multiple studies consider the use of smartphones as fundamental for communication within the hospital, as well as for searching information in a faster way. However, there is concern about how these devices might cause distractions and errors, affecting the quality of care and patient safety. Most studies agree on the potential of new technologies to improve the performance and quality of care offered in hospitals and agree that the negative effects of mobile use in healthcare settings are not supported by consolidated and reliable data [1, 2]. Indeed, mobile applications have been successfully used in different healthcare contexts [3]: for the safe and effective prescription and administration of drug treatments medication, for consulting articles, cases, and medical news [4, 5]. According to the evaluation and management of clinical practices, different studies have been carried out in the Anglo-Saxon environment, with good results [6], [7]; however, in the Spanish environment, although similar tools have been developed in recent years for assessing standard competencies [10], or for managing practice-related issues [9], there are still no papers showing its results.

The main goal of this work is to design and implement a computer application to support the evaluation of clinical practicum carried out by students of Nursing Degree in hospitals or health centers, through a set of questionnaires that can be completed during clinical nursing practise, to confirm the competencies acquired continuously. In addition, recording the students' attendance at the clinical placement through the application would be useful too. On the one hand, it is important to know which professional from the centre is supervising each student at any given moment, in order to have a quick reference in the event of a biological accident in the hospital; on the other hand, it is necessary to know, for each student, which professionals he have spent the most time with, as they will be the ones participating in his evaluation.

The solution presented in this paper makes it possible both to confirm that students have completed the number of hours of clinical training needed to obtain their degree and to ensure that they have acquired the expected competences. This would guarantee that every student finishes his degree having obtained the necessary training provided by these placements. Finally, the application also supports the publication of relevant information for the students by health professionals and university lecturers. This information can be of any kind, such as messages from the university to the students on administrative issues, messages from hospital professionals explaining different techniques, information on how to proceed in case of biological accidents during the internship (e.g., if a student is pricked by a contaminated needle), etc.

II. Analysis

At the beginning of this work, a first meeting was held between the co-authors from the Nursing Department (hereafter, the experts) and the co-authors from the Computer Science Department. At this meeting, the main needs in this specific context were discussed; the details of the evaluation of clinical practices were analysed; additional functionality was suggested to facilitate and improve the experience for students, university professors and professionals in charge of these students; and a first proposal for a solution to the problem raised was outlined.

In order to better understand the needs to be covered, it is necessary to explain some previous concepts related to the management of clinical practices as well as to the users involved and their tasks in this context.

A. Definitions

Unit: Department of the hospital or health center where the clinical practicum takes place (e.g., Internal medicine, Surgery, or Paediatrics).

Rotation: Period during which a student is assigned to a unit. During a rotation, students work under the supervision and guidance of experienced nurses. There are six rotations for students of the Degree in Nursing at UAM. Students must be assessed, on each rotation, by the specialists in their unit who oversee them.

B. Questionnaires

The questionnaire used to assess student performance currently consists of 48 items organised in 7 blocks (called "dimensions") relating to: adaptation to the practice context; teamwork; clinical decision-making process; integration of ethical principles in care; implementation of nursing interventions; communication with the patient and family; and self-learning management. The tutor must answer each question with "yes", "no" or "not assessable" and must assign a mark to each dimension to assess the acquisition of the competences corresponding to it.

The members of the Department of Nursing co-authoring this paper have recently worked on the creation of a new extended assessment questionnaire with a total of 99 items, organised in the same 7 blocks, in which the number of possible answers for each question increases from 3 to 5, allowing a more precise mark to be assigned to each assessable competence. In this way, the score for each dimension can be calculated from the answers to these questions, providing a more rigorous final assessment to be obtained. This new questionnaire was developed from a literature review. Content validity was established by an expert panel of 12 nursing experts. In this moment, this panel is working on the analysis of reliability and validity of the questionnaire.

C. Users

Students: users who are taking a supervised practice course in the Nursing Degree and, therefore, are doing a clinical rotation in a hospital or health center. They are under the care of an academic tutor, who is accountable to them at the university. In the hospital or health center, they are usually under the supervision of a clinical tutor, although sometimes this is not the case. Each student can be at a clinical unit in the morning shift (from 8:00 to 15:00) or in the afternoon one (from 15:00 to 22:00). The students must attend for a minimum number of hours; otherwise, they must repeat the clinical rotation.

Academic tutors: UAM lecturers in charge of a group of students doing clinical practice. Their role is to keep in touch with clinical tutors and correct students' academic works. They need to obtain the students' evaluations at the end of each rotation in order to assign the grades for the corresponding practical subjects.

Clinical tutors: nurses that work where the students do their clinical rotation. Every nurse can confirm the attendance of the students, but only clinical tutors can supervise the students' practice and fill in the evaluation reports at the end of the rotation. Occasionally, some students have no clinical tutor associated. In these cases, the professionals from the unit with whom the student has spent most of the time meet, and jointly complete the evaluation report for him.

Administrators: they are usually university lecturers responsible for the coordination of clinical practicum for each degree. They manage all the information on users, units, and rotations.

III. Design

After the first meeting with the experts, a first catalogue of functional and non-functional requirements was drawn up, which was refined and validated with them in subsequent meetings. The experts were involved throughout all the process. The sub-systems into which the application is divided are:

A. *Assessment Subsystem*

It supports everything related to the assessment of students by the clinical tutors (hospital professionals). They are shown the two evaluation questionnaires. On the one hand, they can access the official questionnaire that is currently used to assign the marks to students, which must be filled in at the end of the practicum. On the other hand, they can access the new questionnaire, which allows for a more comprehensive assessment of the students' competences and to record the acquisition of competences at any time during the practicum, so that students and tutors can keep track of the students' progress. In it, professionals can register comments on the assessment and the final total mark is automatically calculated based on the evaluations recorded in the different dimensions. This second questionnaire is in the process of being officially approved for compulsory use but is already available through the application. Its completion so far is voluntary.

B. *Attendance Subsystem*

It includes all the functionality for managing student attendance at the hospital. Clinical tutors can search for the student in their unit and mark that he is present in the hospital, specifying the check-in time. They can also indicate that a particular student has left. If a clinical tutor forgets to check-out a student, this student appears in a section of the application called "Students pending to check out", and she is allowed to check out at any time. A student can search for a specific clinical tutor in his unit and send her an attendance signature request (e.g., in case she has forgotten to check in); the student inserts the date and time of check-in and check-out, and the clinical tutor can accept, modify, or reject the request. In addition, all users with access to a student's information (administrators, clinical tutors, academic tutor, and the student himself) can view his attendance record.

C. *Information subsystem*

It includes the functionality that allows the publication and visualisation of messages, protocols, and other useful information for students. Clinical or academic tutors can publish information that is organised according to categories previously established (e.g., messages, action protocols, procedure explanations, or any other category they may wish). Administrators can publish information for students in the units and rotations of their choice. Clinical tutors can publish information only for the students associated to their unit. Edition and deletion of published content is also allowed.

D. *User subsystem*

It supports the management of user profiles, access, and permissions. Access is controlled by username and password. The corresponding permissions are granted to each profile, so that administrators can manage users, units and rotations, and the rest of the users can access the functionalities that correspond to each of them. Regarding the permission to fill in a student's evaluation questionnaire, if the student has a clinical tutor, she will be the one to complete it; if he has not been assigned to a clinical tutor, the three professionals in the unit with whom the student has worked most of the time will be the ones allowed to fill it in.

IV. THE APPLICATION

A. *Interaction and interface design*

Once all the functional and non-functional requirements of the application had been identified, and the main aspects of the system had been analysed and designed, mock-ups were created to depict the interface and interaction design, as well as to validate it with the experts. The principles and guidelines for interactive interface design were considered [10, 11]. Figma, a free, cloud-based tool widely used by user experience and user interface (UX/UI) designers, was used to develop the mock-ups. This tool is specialised in user interface design and offers very entire functionalities for prototyping.

The strategy followed to validate the interaction and interface design was as follows. A first prototype was developed. Meetings with the experts were held to show them the prototype and obtain their feedback. Thanks to this feedback, it was possible to modify some design details and proceed to implement the application. Fig. 1 shows the mock-up of the attendance tab in which clinical tutors record student attendance.

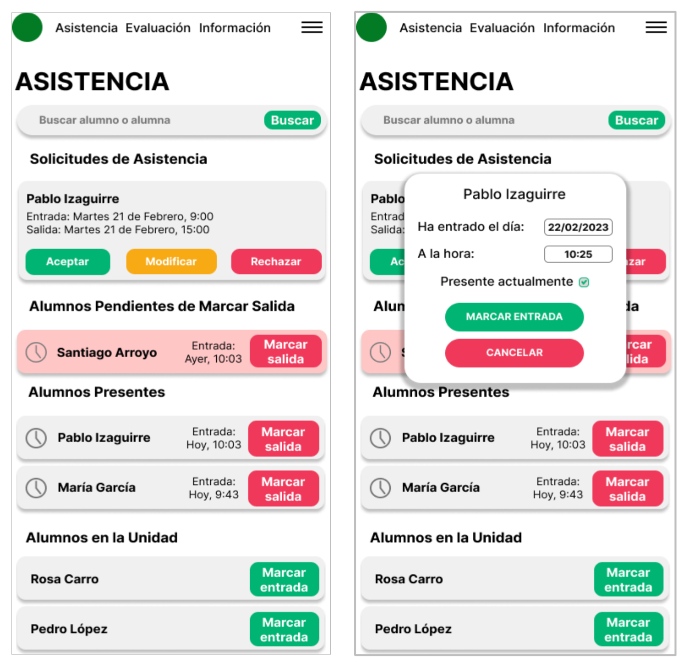
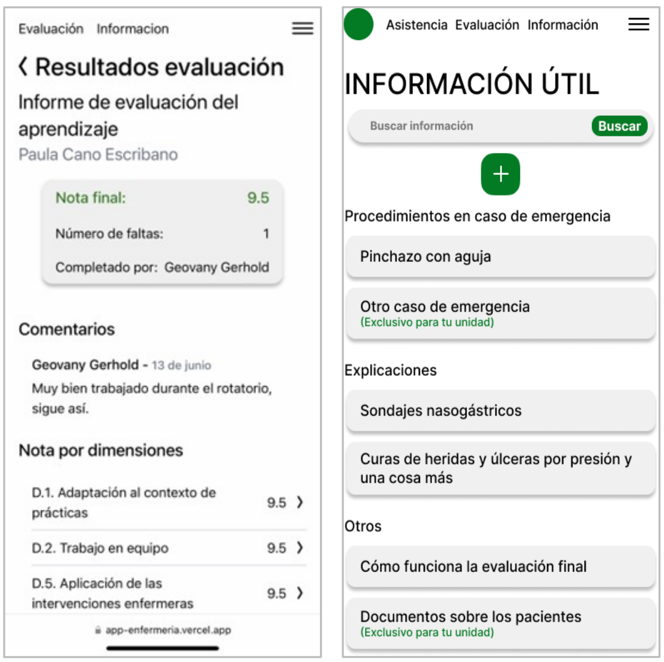


Fig. 1. Mock-up of the tab where attendance is managed

To support the student assessment, several design alternatives were created. They were presented to the experts to discuss with them which one would be more suitable for the clinical tutors. One example of feedback from the experts that caused changes in the interface is the following: in order to visualise the answers to the questionnaires, it was necessary to scroll through the dimensions to see the mark received in each of them; the experts advocated creating an initial screen in which the scores would be summarised, showing the final total score, the score for each dimension and the possibility of accessing the details of each dimension from this main screen (with no need of navigating between dimensions to find out the score for each of them). The final mock-up for this screen is shown in Fig. 2a.

Regarding the mock-ups developed for inserting and visualising information, they were approved in the validation meetings. Fig. 2b. shows the one for visualisation. As it can be seen, a coherent and common aesthetic has been used throughout the application, based on the use of shaded cards. The predominant colour is the green used when developing UAM institutional resources. Once the design of the application was validated by the experts, the implementation began.



a) b)

Fig. 2. Mock-ups of assessment and information visualization

B. Implementation

For the development of the application, the following technologies have been selected, with the aim of allowing efficient development, scalability of the application, ease of code maintenance and agility in both the creation of user interfaces and data management.

For the frontend development of the application, React.js has been used [12]. React is an open-source JavaScript library used to build interactive user interfaces that enables the creation of reusable components, breaking the interface into smaller, more manageable parts, making it easier to build and maintain the code. In addition, it supports efficiently rendering only the components that change, instead of performing a complete UI update, resulting in better performance and a smoother user experience. The primary programming language used in the application is TypeScript [13], a superset of JavaScript that adds static typing features, providing benefits such as compile-time error detection, better code organization, and greater scalability of the application.

For the development of the backend of the application, TypeScript has also been chosen, making use of Node.js as the server-side execution environment, which has numerous advantages: it is particularly suitable for the creation of efficient and scalable web applications, due to its focus on event handling and its capacity for asynchronous operations, allowing for high performance in high concurrency situations. Thus, if in the future the use of this application is to be extended to other departments of the university, or even to other universities simultaneously, the application will respond efficiently. Other technologies and resources used have been: Next.js [14] as a development framework, Tailwind CSS [15], PostgreSQL [16] as a database manager and Prisma [17] to simplify database access and manipulation.

It is worth mentioning that the application has been implemented using responsive technology to maximise the use of space on mobile devices and to take advantage of larger screens such as those on computers. This type of technology prevents developers from implementing the whole application twice, one for each type of device. Figure 3 shows the different interfaces generated to support the completion of the extended evaluation questionnaire: on the left the version for mobile devices and on the right the one for computers.

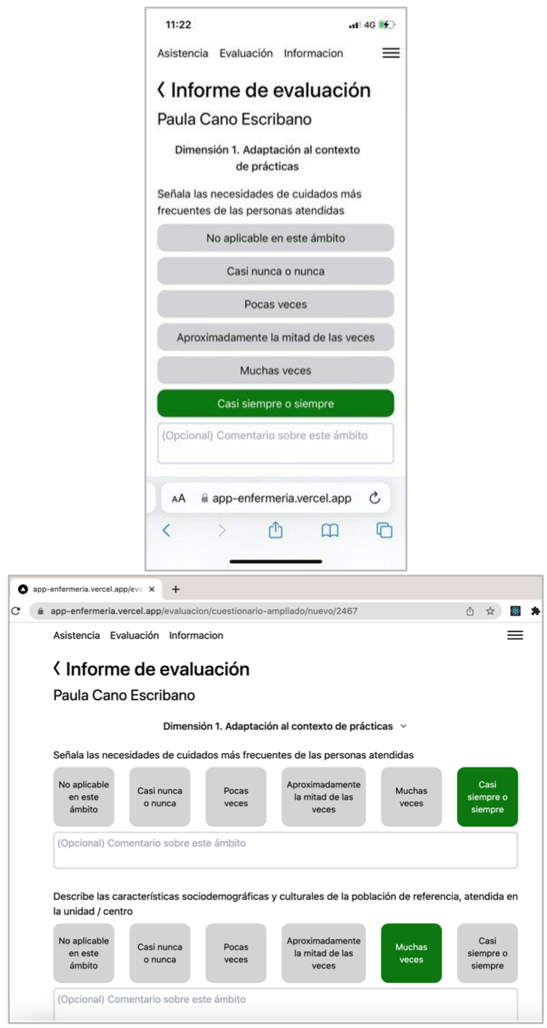


Fig. 3. Screenshots of page to fill in the extended evaluation questionnaire

V. TESTS AND RESULTS

To evaluate the correct functioning of the application while its different functionalities were being developed, a local environment was configured, where a server was run in development mode. All the tests done during the implementation phase verified the proper functioning and performance of the application and corroborated the appropriate design of the interface to support the corresponding tasks.

On the other hand, tests have been carried out with end users, deploying the application and hosting the database in Vercel. These tests have involved volunteer users of the three profiles: students, academic tutors, and clinical tutors. The objectives of this evaluation have been to assess the usability and potential usefulness of the application and to measure user satisfaction, to check if the application meets their expectations and needs, as well as their satisfaction with the overall experience.

To collect all this information, three questionnaires have been developed, one for each type of user. Each questionnaire sets out a series of specific tasks to be performed by the user and presents questions related both to the performance of these tasks and to the usability of the whole application.

The approach to analysing the user-friendliness of the application has been to present only the statement of the tasks to be accomplished, without any other information or help on how to do it, so that users need to explore the application to perform them. This helps to effectively measure whether the application is simple and intuitive. An example of a task to be performed is the following one, proposed to academic tutors to assess the user-friendliness of the attendance record section:

> *"Find your (fictitious) student Paula Cano Escribano and find out which (fictitious) professional she was in hospital with on Wednesday 31 May. See what time she entered the hospital and what time she left".*

For all these tasks, the user was asked whether he/she was able to perform it and whether the interaction was simple and intuitive. In case of answering "no" to any question, the user can write comments in the open text field available next to it, to reflect any difficulties encountered or problems experienced, which provides useful information for future improvements.

On the other hand, to assess the user satisfaction with the different aspects of the application, a set of statements were presented, and a 5-value Likert scale was used to measure the degree of agreement or satisfaction of the user with them. The statements to be assessed deal with specific aspects of the interface (colour contrasts, fonts, organisation of elements shown on the screens, etc.) and interaction (navigation between screens, understanding of buttons and actions that can be performed with them, consistency, ease of use, etc.), and also with other general aspects such as how easy is learning to use the application, user's overall satisfaction with the application, perceived usefulness of the application in the context of nursing practice or whether the user would indeed wish to use it in this context. Special care was taken to ensure that the language used in the questionnaires was not too technical, so that it could be easily understood by all types of users, even those with little familiarity with new technologies.

So far, responses have been collected from 9 users: 5 academic tutors, 1 clinical tutor and 3 students. The results show a very positive evaluation of the application, as it can be seen in the graphs shown in Fig. 4: all users selected "Strongly agree" or "Agree" for statements related to whether they find the application useful and whether they would like to use it.

Fig. 4. User satisfaction: intention of use and application usefulness

In terms of interaction, it was generally well rated. Questions related to the interface were rated very positively too. The lowest rated statements was: *"The contrast of colours makes it possible to see the texts and buttons on the screen well"*: 11% users answered "Neutral", 33% answered "Agree" and 56% answered "Strongly agree", which is not a negative result either.

As for the proposed tasks to be performed by the users, out of the 20 tasks to be performed, only one user was unable to perform one task: *"Visualise which hospital professional a student was with on a certain day"*. This indicates that the design of the interaction for this task should be revised or explained, perhaps by introducing a help button.

The information entered by users in the text fields for comments and suggestions also proved very valuable, such as that proposing to display more feedback messages indicating what actions have been performed (e.g., when posting new information for the students). This will be incorporated into future updates of the application. As the application is web- based, it is very simple to make updates available to users.

VI. CONCLUSIONS AND FUTURE WORK

We have designed and implemented an application for the automated and efficient digital management of some aspects of the clinical practicum in Nursing Degree at UAM: the student continuous assessment through detailed questionnaires of competence acquisition; the management of student attendance for clinical rotations; and the publication of useful information for the students in a simple way. This is supported with the intention of providing a better experience for clinical tutors and students during the clinical practise in hospitals or health centers.

This digital assessment provides continuous feedback to students on their performance throughout the practicum, enables clinical tutors to assess the competencies acquired by the students as the rotation progresses, and allows academic tutors to consult all this information at any time. On the other hand, the attendance system developed is intuitive and provides a secure and reliable way to keep track of student attendance. Finally, the publication of useful information for students contributes to their training in this context.

The involvement of the experts in the different phases of development (initial identification of the problem and its scope; requirement analysis; validation of the interface and interaction design through prototyping testing; and final evaluation) has been of great added value.

The guidelines followed for the interface and interaction design, as well as the technology used for its implementation, have resulted in a scalable and robust application, with an attractive user interface that complies with the principles of usability, thus improving the user experience.

According to the comments and suggestions provided by the users who have evaluated the current version of the application, we are considering the possibility of increasing the number of feedback messages, offering help messages to perform some more complex tasks, and increasing the colour contrast in some sections of the application.

On the other hand, it would be interesting if each student could obtain a count of the number of times that they have practised the different nursing techniques. This would be useful, for example, to incorporate this information in their curriculum vitae as a summary, which is common in the healthcare field.

We also plan to support students to enter comments on the techniques performed each day (e.g., notes on something they learned and want to remember, doubts they had and how they were solved, how they felt, how they performed the technique, etc.); they could also note or link information on how to perform those techniques.

Once the new assessment questionnaire is formally approved, it is planned to use the application for the assessment of clinical practice competences in Nursing Degree at UAM. The current version of the application is available at Vercel. The necessary steps for its deployment in a production environment at UAM (which includes hosting it on UAM cloud servers) are currently underway.

Once the application is widely used in this context, its use could be extended to other degrees. In fact, there is interest in using it in the UAM Medicine Degree. The requirements for the development of an additional module for the medical practicum are currently being analysed. In addition, we are exploring the possibility that other universities, with which contact has been established for the psychometric validation of the competence assessment questionnaire, may be interested in using the application. For the time being, the application is available in Spanish. However, it would be interesting to translate it into other languages for non-Spanish universities to test its effect in different countries.

Acknowledgment

The authors thank the clinical tutors, academic tutors and students who have voluntarily participated in the evaluation of this application and those who are working to promote and support its use in the hospitals and health centres where UAM Nursing Degree students do their practicums.

References

[1] M. Fiorinelli, S. Di Mario, A. Surace, M. Mattei, C. Russo, G. Villa, S. Dionisi, E. Di Simone, N. Gian- netta, and M. Di Muzio, “Smartphone distraction during nursing care: Systematic literature review,” Applied Nursing Research, vol. 58, p. 151405, 2021.

[2] H. Yahya, “Healthcare-related smartphone use among doctors in hospitals in kaduna, nigeria–a survey,” Nigerian Journal of Clinical Practice, vol. 22, no. 7, pp. 897–905, 2019.

[3] M. A. Mayer, O. Rodríguez Blanco, and A. Torrejon, “Use of health apps by nurses for professional purposes: Web-based survey study,” JMIR Mhealth Uhealth, vol. 7, p. e15195, Nov 2019.

[4] P. Frishauf, “Medscape–the first 5 years,” Medscape General Medicine, vol. 7, no. 2, p. 5, 2005.

[5] A. Patel, “The number one downloaded medical app for the iphone–medscape [app review].” Available a t: https://www.imedicalapps.com/2010/05/ medscape-iphone-medical-app- review/, 2010. Accessed: 17 June 2023.

[6] Strandell-Laine, C, Saarikoski, M, Löyttyniemi, E, Meretoja, R, Salminen, L, Leino-Kilpi, H. Effectiveness of mobile cooperation intervention on students’ clinical learning outcomes: A randomized controlled trial. J Adv Nurs. 2018; 74: 1319–1331. https://doi.org/10.1111/jan.13542

[7] Clay CA. Exploring the use of mobile technologies for the acquisition of clinical skills. Nurse Educ Today. 2011 Aug;31(6):582-6. doi: 10.1016/j.nedt.2010.10.011. Epub 2010 Nov 26. PMID: 21112132.

[8] Intelligenia, “Unipracticum : intelligenia - web and app.” Available at: https://www. intelligenia.com/unipracticum, n.d. Accessed: 17 June 2023.

[9] F. J. Díaz, “Gesdoc: gestión digital, seguimiento y evaluación de prácticas clínicas | escuela universitaria de enfermería - fundación jiménez díaz..” Available at: https://www.fjd.es/escuela-enfermeria/en/estudiantes/practicas-clinicas/ gesdoc-gestion-digital-seguimiento-evaluacion-practicas-cli, n.d. Accessed: 17 June 2023.

[10] B. Shneiderman, C. Plaisant, M. S. Cohen, S. Jacobs, N. Elmqvist, and N. Diakopoulos, Designing the user interface: strategies for effective human- computer interaction. Pearson, 2016.

[11] U. de Oviedo, “Guía practica de diseño de la interacción con el usuario.” Availableat: http://di002.edv.uniovi.es/~alguero/eaac/Ensenianza/GUIAP.pdf, Accessed: 17 June 2023.

[12] S. Aggarwal et al., “Modern web-development using reactjs,” International Journal of Recent Re- search Aspects, vol. 5, no. 1, pp. 133– 137, 2018.

[13] G. Bierman, M. Abadi, and M. Torgersen, “Understanding typescript,” in ECOOP 2014–Object- Oriented Programming: 28th European Conference, Uppsala, Sweden, July 28–August 1, 2014. Proceedings 28, pp. 257–281, Springer, 2014.

[14] K. Konshin, Next. js Quick Start Guide: Server-side rendering done right. Packt Publishing Ltd, 2018.

[15] T. CSS, “Tailwind css.” Available at: https://tailwindcss.com/, n.d. Accessed: 17 June 2023.

[16] B. Momjian, PostgreSQL: introduction and concepts, vol. 192. Addison- Wesley New York, 2001.

[17] Prisma, “Prisma orm.” Available at: https://www.prisma.io/, n.d. Accessed: 17 June 2023.

HERSTORY: COMBATING GENDER STEREOTYPES BY HIGHLIGHTING WOMEN'S CONTRIBUTION TO THE HISTORY OF SOCIETIES

Lucía García-Holgado
GRIAL Research Group
Research Institute for Educational Sciences, Universidad de Salamanca
Salamanca, Spain
luciagh@usal.es

Alicia García-Holgado
GRIAL Research Group
Research Institute for Educational Sciences, Universidad de Salamanca
Salamanca, Spain
aliciagh@usal.es

Sonia Verdugo-Castro
GRIAL Research Group
Research Institute for Educational Sciences, Universidad de Salamanca
Salamanca, Spain
soniavercas@usal.es

Erika García Silva
GRIAL Research Group
Research Institute for Educational Sciences, Universidad de Salamanca)
Salamanca, Spain
erika.garcia@usal.es

Francisco J. García-Peñalvo
GRIAL Research Group
Research Institute for Educational Sciences, Universidad de Salamanca
Salamanca, Spain
fgarcia@usal.es

Antrea Kosta
Advisory Center for the Support of the Family, SIKESO,
Nicosia, Cyprus
antrea@sikeso.org

Dimitra Sofianou
KEAN-Cell of Alternative Youth Activities
Athens, Greece
d.sofianou@kean.gr

Emily Psara
Center for Social Innovation Cyprus
Nicosia, Cyprus
emily.psara@csicy.com

Miguel Á. Conde
Department of Mechanics, Computer Science and Aerospace Engineering, Robotics Group, Universidad de León
León, Spain
mcong@unileon.es

***Abstract*—HerStory project addresses the need of European Union (EU) to combat gender-based stereotypes, a priority underscored by the EU Council. Also, it adheres to the main aim of the EU Gender Equality strategy 2020-2025, of "Leading equally throughout society" as well as the objectives of the Gender Action Plan III. The project's goal is to highlight the significant contribution of women in history across European cities. HerStory aims to develop a transnational map that will feature important women from different regions shedding light on important historical moments where women's actions were decisive. This initiative will tackle the gender stereotypes that often exclude women from decision-making bodies, whether in politics and social life or work. At the same time, it will promote positive role models operating as an empowerment tool for girls and women. The project's outcomes will provide capacity building and useful methods to youth experts, educators, academics representing a conscious effort to shift gender-related attitudes through education and youth engagement.**

Keywords*— *Gender stereotypes; Women; history; Equality; European Union; HerStory; Gender gap

I. INTRODUCTION

History reflects power dynamics. Traditionally, the field of history was guided by a male dominated perspective. This fact encourages societies to value men, their roles in shaping society and their accomplishments more than those of women. Historiography lacks basic information about women's action in history. As the mainstream literature on women's history is limited, their contribution to society and the struggles for women's rights remain largely invisible.

The lack of visibility of women in history is reflected both in the scarcity of statues representing women in history and the limited knowledge about where these statues are located and what they represent. By focusing on women's triumphs and normalizing the success through the public display of women's statues and monuments, these historical misconceptions and misrepresentations can be addressed. Previous initiatives have tackled the problem in particular areas, such as astronomy [1] and art [2].

We can tackle existing stereotypes regarding the value of women in society by re-visiting local histories and the popular narratives they support. In this way, HerStory project (Table 1) will combat gender-based stereotypes while empowering women and girls around Europe. A key component of this project is the use of technological means to provide transnational digital history journey highlighting different statues, monuments, places, that represent the footprint of women in history in cities across Europe. The project will develop a transnational map where visitors will be able to find remarkable places related to women in history, read their story and find useful resources regarding them. Participants will be able to visit in person these historical points through small tours and activities in European cities involved in the project.

The target groups of the HerStory project include youth/students, feminist organizations, youth organizations, human rights organizations, women organizations and collectives, school educators, and academic researchers in various fields including history, sociology and anthropology. These direct and indirect groups are the primary recipients of the project's initiatives and activities, aiming to promote gender equality, historical awareness, and women's empowerment through education, research, and collaboration.

This article describes the project in five sections. The second section present the partnership involved in the project. The third section describes the project objectives and workplan. The fourth section present the main results of the project and the final section summarizes the main conclusions.

TABLE I. PROJECT DETAILS

Title	HerStory - Combating gender stereotypes by highlighting women's contribution to the history of societies
Acronym	HerStory
Funding Entity	European Union
Call	Citizens, Equality, Rights and Values Programme. CERV-2022-GE - Call for proposals to promote gender equality
Reference	101087984
Coordinator	Universidad de Salamanca (USAL)
Partners	D'antilles Et D'ailleurs (DA&DA) Symvoyleytiko Kentro Stirithis Tis Oikogeneias (SYKESO) Kyttaro Enallaktikon Anazitiseon Neon (K.E.A.N) Vazmozhnosti Bez Granitsi (IOA) Andragoski Zavod Ljudska Univerza Velenje (LUV) Center For Social Innovation (CSI) VSI Diversity Development Group (DDG) Specchio Magico Cooperativa Sociale Onlus (SM)
Budget	506.152,80 €
Start date	16/01/2023
End date	15/01/2025
Web	https://herstoryproject.eu/

II. THE CONSORTIUM

The coordination of the project is the responsibility of the GRIAL Research Group [3] of the University of Salamanca (USAL). This Research Group is an integral part of the Research Institute of Educational Sciences (IUCE), ensuring the connection between the project and its' primary target groups; that is young students, and future teachers that can introduce the HerStory resources in their lessons.

The consortium comprises nine European institutions from eight European countries (Fig. 1), offering a diverse range of expertise and experiences that align with the scope and objectives of the HerStory project. These institutions collectively possess a Pan-European outreach in their activities, ensuring a broad and comprehensive approach to project implementation:

- The University of Salamanca (USAL), represented by the GRIAL, bring their expertise to effectively coordinate, monitor, and evaluate international initiatives. Moreover, GRIAL has a long history of working on promoting gender equality, further bolstering its dedication to fostering inclusivity and equity [4-7].
- D'Antilles et d'Ailleurs (DA & DA) in Martinica (France) specializes in promoting active participation in civil society, particularly focusing on young people and migrant women facing limited opportunities. Their efforts support access to social rights, employability through inclusive entrepreneurship, and digital inclusion.
- The Advisory Center for the Support of the Family (SIKESO) was established in 2007 in Cyprus with the aim of providing guidance and support to individuals, groups, and families in need. Through its extensive network of collaborators, SIKESO implements projects at the local and national levels, working in collaboration with Non-Governmental Organizations, Local Authorities, Associations, semi-governmental organizations, and governmental departments. Key priorities include promoting gender equality, addressing gender-based violence, and empowering and training young people on issues related to equality and diversity.
- KEAN, based in Greece, places significant emphasis on supporting social minorities and disadvantaged groups through its collaborations in both the public and private sectors. Their efforts encompass a wide array of activities, including strategic partnerships, educational and training workshops, scientific research and analysis, advocacy, round table discussions, volunteering activities, sports events, dissemination, visibility, and awareness-raising initiatives.
- IOA, based in Bulgaria, is actively involved in projects that prioritize human rights education and social inclusion for marginalized communities. Their initiatives include empowering young girls from vulnerable groups, running awareness campaigns on human rights and equality, and combating gender prejudice through media tools.
- AZ Ljudska Univerza Velenje (LUV), based in Slovenia, plays an active role in the local community by motivating and informing individuals and providing them with educational opportunities through both formal and non-formal methods. Notably, the organization utilizes unique interactive digital tools that incorporate playful learning methodologies, engaging learners in an innovative and enjoyable way.
- The Centre for Social Innovation (CSI) is a dynamic Research and Development organization from Cyprus dedicated to fostering social innovation for positive change on various levels, from local to global contexts. CSI possesses the expertise and resources to identify social needs, design tailored initiatives, and ensure sustainable growth. Their areas of expertise include education and e-learning, and they have a proven track record of delivering sophisticated solutions to enhance efficiency and service quality for both public and private organizations.
- VSI Diversity Development Group (DDG), based in Lithuania, is a non-profit organization that actively engages in scientific, applied, and infrastructural projects focused on various areas, including human rights, education, equal opportunities, diversity, migration, integration, and youth. DDG possesses extensive expertise in developing methodologies and training courses.
- Specchio Magico (SM), based in Italy, collaborates with educational institutions to address critical topics such as active citizenship, inclusion, and the prevention of domestic and sexual violence. They employ pedagogical methodologies and approaches tailored to early childhood, children, and young people.

Fig. 1. Countries involved in HerStory

III. The Project

A. Objectives

The European Union (EU) Gender Equality strategy 2020-2025 refers to "Leading equally throughout society" as the primary objective for the Union and its member states. Thus, "achieving equal participation across different sectors of the economy" and "achieving gender balance in decision-making and in politics" are crucial steps towards reaching gender equality. EU calls the member states to implement measures encouraging women's participation in these areas, tackling as a first step the gender stereotypes that limit barriers in women's opportunities and reinforce male domination. In this context, it is of vital importance to challenge stereotypical gender roles while empowering girls and women.

Recognizing the achievements of women in all facets of life has a significant impact on the development of self-respect and opens new opportunities for girls and young women. To this end HerStory will function as a tool for women's empowerment.

The main objective of the HerStory project is to shed light on the significant contributions of women throughout history in cities across Europe. This is achieved through the development of a transnational map showcasing influential women in different areas, including politics, society, sciences, and the arts and highlight key historical moments shaped by women's actions. HerStory challenges existing stereotypes and emphasizes the societal value of women.

The project's specific aims in support of these objectives, include:

- Tackling gender stereotypes on social media, focusing on stereotypes that influence young people's career choices.
- Increasing awareness of existing online mechanisms that reinforce gender stereotypes and are related to professional life and career opportunities.
- Promoting a different way of communicating/representing gender roles in employment/career opportunities on social media.

B. Workplan

The work plan of HerStory is broken down into several overlapping phases including (i) research and analysis, (ii) design and development, (iii) testing and implementation, (iv) validation and localisation, and (v) communication and exploitation of project outputs.

The project is structured into on the following Work Packages (WP) as illustrated in Fig. 2:

- WP1 – Project Management, Monitoring and Quality Assurance: An overarching work package that monitors the project activities' timely and high-quality implementation within the pre-determined budget.
- WP2 – Research and Mapping Local Women Histories.
- WP3 – Development of HerStory Map, Online Platform and Mobile App
- WP4 –Exploring HerStory Map: Learning and Training Activities Implementation
- WP5 – Dissemination and Sustainability. This WP develops the project's overall dissemination and communication plan, dissemination products and awareness raising activities.

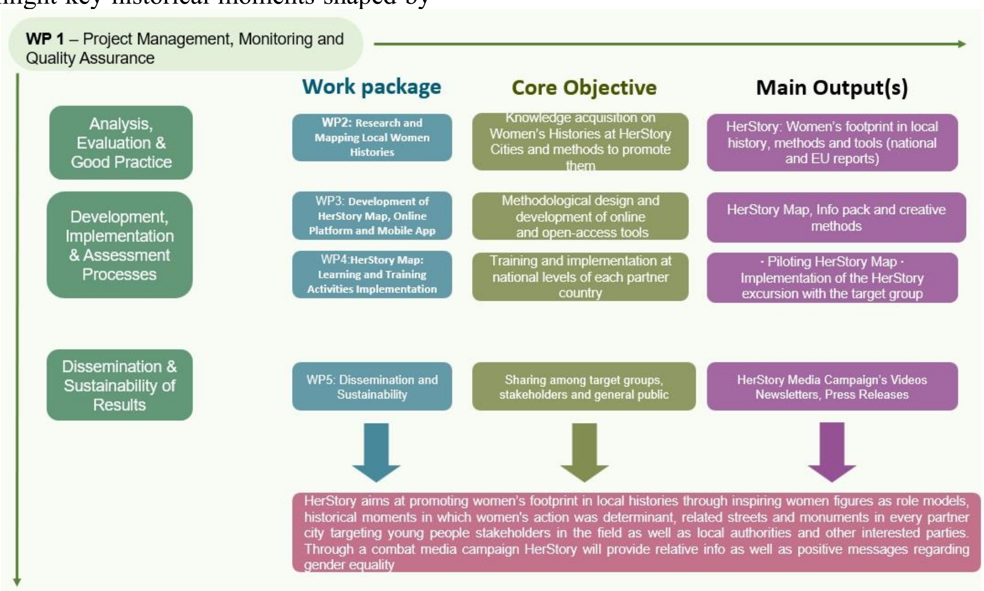


Fig. 2. Workplan

IV. Project Results

C. Research and Mapping Local Women Histories

The second work package will guide the project's research efforts and critically examine the current state of the art, best practices, needs and expectations of target groups. During this work package the partners will conduct desk research on the footprint of women in history investigating their city's history. In particular, the target cities are Salamanca in Spain (GRIAL-USAL), Fort-de-France in Martinique- France (DA & DA), Nicosia in Cyprus (SYKESO and CSI), Athens in Greece (KEAN), Sofia in Bulgaria (IOA), Velenje in Slovenia (LUV), Vilnius in Lithuania (DDG) and Lecco in Italy (Specchio Magico Cooperativa Sociale Onlus).

Also, through two focus group discussions they will conclude to best practices for highlighting of women's hidden history as a means of empowering women and promoting gender equality. The main outputs will be the transnational and national reports as well as to the HerStory Methods Manual. The manual will include suggestions for creative and innovative methods to explore the HerStory Maps physically (gamification activities/ treasure hunt etc.). Both will serve as the steppingstone and the foundation of the project.

D. Development of HerStory Map, Online Platform and Mobile App

The third work package develops the transnational women history map which will be available via an online platform and a mobile app. Through the HerStory online platform hosted on the project's website as well as the HerStory mobile application, users will be able to access the HerStory Transnational Map consisting of the HerStory Maps of the partner cities. Upon visiting the map, user will have the opportunity to gather information regarding a) inspiring women from different fields, b) historical moments connected with cities' spots where the contributions of women were important, c) streets and monuments related to women and their achievements.

The information will be extracted through texts, photos, and videos developed in conjunction with the HerStory media campaign. At the same time, users visiting the HerStory Online Platform and Mobile App will find activities which enable them physically to tour each partner city. These activities, such as treasure hunts, using methods such as gamification, will be both creative and entertaining while providing knowledge about women's footprint in history, promoting positive messages regarding gender equality.

The transnational map will be based on WordPress. The map will be developed as a plugin to facilitate the integration in the project website. The map will allow moving through the different partner cities. Moreover, the plugin will be prepared to support multilingual; the national maps will be in English and in the national language.

Regarding the mobile app, it will be available for iOS and Android to cover most of the devices available in the market. The app will facilitate the access to the transnational map to provide a better user experience when the participants in the activities are visiting the different spots.

E. Exploring HerStory Map: Learning and Training Activities Implementation

During this stage, the target group will physically explore the HerStory Map in each partner city. During the first phase of the fourth work package, partners will organize piloting tours of the map by utilising the creative and entertaining methods provided in the HerStory online platform and Mobile App aiming to identify any potential errors or weaknesses.

After the necessary adjustments are made, they will move on to the second phase which will be the actual implementation of the HerStory Map Tour with a number of 180 participants coming from the direct target groups at each partner city: young people, students from the fields of History and Gender Studies, as well those active in local communities' groups, and youth experts, academics from the fields of History and Gender Studies, teachers, and women and human rights organizations experts and activists at each partner country. At the end of each tour, participants will evaluate the entire experience.

V. Conclusions

The HerStory project aims to challenge existing gender stereotypes and empower women and girls across Europe by highlighting the significant contributions of women in history. The project's main objective is achieved through the development of a transnational map that showcase influential women and key historical moments shaped by their actions. By utilizing technological means, such as an online platform and mobile app, the project enables users to explore the map and learn about inspiring women, historical sites, and achievements. Through research and mapping efforts, the project gathers valuable information on women's hidden histories and promotes empowerment and gender equality. The implementation of learning and training activities allows the target groups to engage physically with the HerStory map, fostering knowledge and positive messages related to gender equality. The piloting tours and subsequent implementation of the map tour provide an opportunity for evaluation and improvement. Overall, the HerStory project contributes to a more inclusive and accurate representation of women's contributions in history, challenging stereotypes and promoting gender equality.

Acknowledgment

HerStory - Combating gender stereotypes by highlighting women's contribution to the history of societies is a project funded under European Union Citizens, Equality, Rights and Values (CERV) Programme (Ref. 101087984). The European Commission's support for the production of this publication does not constitute an endorsement of the contents, which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

References

[1] A. Lear and K. Taylor, "A woman 'in the snow among the clocks and instruments': How Adrienne Rich reimagined the lives of women astronomers," *Acta Astronauti-ca,,* vol. 207, pp. 283-294, 2023, doi: 10.1016/j.actaastro.2023.03.025.

[2] J. R. Moreno Vera and M. I. Vera-Muñoz, "QR-Learning: la invisibilidad de la mujer en el arte," *Revista Estudios,* vol. 33, 2016. [Online]. Available: http://rua.ua.es/dspace/handle/10045/61672.

European Union. Citizens, Equality, Rights and Values Programme. CERV-2022-GE - Call for proposals to promote gender equality

[3] F. J. García-Peñalvo, M. J. Rodríguez-Conde, R. Therón, A. García-Holgado, F. Martínez-Abad, and A. Benito-Santos, "Grupo GRIAL," *IE Comunicaciones. Revista Iberoamericana de Informática Educativa,* vol. 30, no. 33-48, 2019.

[4] A. García-Holgado *et al.*, "Preliminary validation of ENGAME: fostering civic participation and social inclusion through an e-learning game," in *Learning and Collaboration Technologies. 10th International Conference, LCT 2023, Held as Part of the 25th HCI International Conference, HCII 2023, Copenhagen, Denmark, July 23–28, 2023, Proceedings, Part II*, P. Zaphiris and A. Ioannou Eds. Cham: Springer, 2023, pp. 466–481.

[5] S. Verdugo-Castro, M. C. Sánchez-Gómez, and A. García-Holgado, "University students' views regarding gender in STEM studies: design and validation of an instrument," *Educ. Inf. Technol.,* vol. 23, 2022, doi: 10.1007/s10639-022-11110-8.

[6] A. García-Holgado and F. J. García-Peñalvo, "A Model for Bridging the Gender Gap in STEM in Higher Education Institutions," in *Women in STEM in Higher Education: Good Practices of Attraction, Access and Retainment in Higher Education*, F. J. García-Peñalvo, A. García-Holgado, A. Dominguez, and J. Pascual Eds., (Lecture Notes in Educational Technology. Singapore: Springer, 2022, pp. 1-19.

[7] D. Fonseca *et al.*, "CreaSTEAM. Towards the improvement of diversity gaps through the compilation of projects, best practices and STEAM-Lab spaces," in *Proceedings of the Ninth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'21) (Barcelona, Spain, October 26-29, 2021)*, M. Alier and D. Fonseca Eds. New York, NY, USA: ACM, 2021, pp. 92-97.

INSTRUCTIONAL DESIGN MODELS FOR IMMERSIVE VIRTUAL REALITY - A SYSTEMATIC LITERATURE REVIEW

Maria Castelhano
Universidade do Porto & Universidade Aberta
Porto, Portugal
up202210803@up.pt

Leonel Morgado
Universidade Aberta & INESC TEC
Coimbra, Portugal
leonel.morgado@uab.pt

Daniela Pedrosa
Instituto Politécnico de Santarém & CIDTFF
Santarém, Portugal
daniela.pedrosa@ese.ipsantarem.pt

***Abstract*—The emergence of accessible virtual reality headsets in the past decade multiplied educational uses of immersive virtual reality. Higher education, in particular, has seen many such reports emerge. However, there are scarce frameworks for higher education professionals to plan and deploy immersive virtual reality within their pedagogical practice. To attain a perspective on this field, we conducted a systematic literature review using SCOPUS search, focusing on Instructional Design Models for Immersive Virtual Reality in online Higher Education. This review aimed to provide a comprehensive overview of these models, their respective phases, and distinctive characteristics. The review identified two categories of Instructional Design Models for Immersive Virtual Reality in Higher Education: 1) Models specific to such contexts, with aspects such as managing immersion time or providing prior contact with the immersive environment; 2) Models developed for other contexts and adapted to immersive virtual reality, addressing aspects such as the importance of creating objectives, assessment elements, or defining resource purpose. We conclude that current instructional models used for immersive virtual reality in higher education lack the combination of the overall pedagogical concerns with the specific ones for immersive virtual reality. Thus, we recommend further research to develop instruction models that combine both aspects of learning design concerns.**

Keywords—instructional models, instructional frameworks, immersive virtual reality, VR, online higher education

I. INTRODUCTION

Virtual Reality (VR) has reemerged in the last decade, given availability of powerful and cost-effective headsets, as a promising technology for enhancing pedagogical practices in higher education. With its spatially immersive and interactive nature, headset-based VR (henceforth, "immersive VR") offers unique opportunities for creating engaging and effective learning experiences. However, to effectively employ immersive VR in pedagogical practice, one needs well-designed instructional models, aligned with principles of instructional design and educational technology standards.

In this paper, we present a systematic review and comparison of instructional design models for immersive VR in higher education. We aim to identify existing instructional design models specifically tailored for VR-based instruction, analyze their phases and characteristics, and compare them based on the standards set by the Association for Educational Communication and Technology. Furthermore, we conduct content analysis to identify adaptations and recommendations proposed by these models to use of immersive VR as a teaching tool.

II. THEORETICAL BACKGROUND

The technological evolution of society has been an integral part of transformations in education, through the inclusion of technologies in the teaching and learning process [1], [2]. With the evolution of technology, new formats of education have emerged, based on immersive learning environments [3], driven by advances in technologies such as real-time graphics, haptic input-output devices, motion sensors, and augmented reality (AR) [4]. These immersive environments are where two complex phenomena co-occur: learning and immersion [3]. Immersion overall refers to a state of deep cognitive or physical involvement or absorption in a narrative, an activity or an experience. In the context of learning, immersion can help students focus and engage more deeply with the learning material, leading to improved retention and understanding of the content [3]. In parallel, digital literacy has emerged as a crucial skill set for individuals to live, learn, and work effectively in digital environments [5]. This includes the ability to assess the relevance and purpose of digital information, communication skills in digital environments, skills to create multimedia content, programming, the ability to adopt security and sustainability measures in data protection, and the ability to solve problems and adapt digital resources for different purposes [6]. In addition to these new concepts, new challenges have also arisen, and concepts emerged to address them, such as instructional design. Instructional design has the primary objective of enabling and ensuring the quality of instruction, making it more efficient, effective, and less challenging. It can be described as the process that supports needs analysis, definition of learning objectives, and establishment of evaluative goals and specific outcomes for successful learning. It involves establishing connections between learning theories and the practice of instructional system development [7]–[10]. Together, this interconnection, structuring, and planning of instruction can assist educators in preparing for meaningful learning experiences. Instructional design models typically consist of common elements such as planning, implementation, and evaluation [11]. According to the Association for Educational Communications & Technology, Instructional Design should follow as guidelines 10 Standards for Distance Learning: (1) Purpose; (2) Assumptions; (3) Sequence; (4) Activities; (5) Resources; (6) Application; (7) Assessment; (8) Reflection; (9) Independent Learning; (10) Evaluation. Purpose is the articulation between the goals and objectives and the collaboration between the structure and the student. Assumptions is the consideration of students' prior learning and their ability to employ the technology/tools used in the course. Sequence is the path of learning, affecting the efficient acquisition of knowledge. Activities deal with adaptations to the defined content and learning objectives. Resources deal with the adaptation for technological accessibility. Application is concerned with providing opportunities to apply new learning. Assessment, both continuous and formative, is about including feedback. Reflection is intended to deepen the learning experience. Independent Learning is about including opportunities for feedback, review, and reflection. And finally, Evaluation is about being goal-oriented and grounded on the acquisition of new knowledge, understanding, and skills, and also on the instructor's self-assessment, and on students' self-assessment [12], [13].

In the context of VR, these concepts must consider that it is evolving towards a fully immersive synthetic spatial reality, where the user can experience a completely realistic simulation of a virtual environment. This involves the use of advanced technologies such as motion tracking devices, brain interfaces, and haptic feedback [4], [14]. VR is typically described as a computer graphics technology [15] that allows the user to socially or individually interact in a synthetic environment [14], [15] that provides believable experiences. A technical goal of VR is to completely make the user feel present inside the computer-generated world, giving the impression of having "stepped inside" the synthetic world. VR has been used in K-12 and higher education as a pedagogical tool [19], as well as in various other contexts [16], [17]. Over the years, this technology has been expanding and consolidating in diverse fields of application [14], [15], [18]. This may be due to its technological improvement, but also to the possibilities it offers for better apprehension of the contents by the students and in its ability to enable practical applications, offering the opportunity to learn by doing [14]. In Higher Education, specifically, this technology has been widely used as a teaching resource [15]. Sample areas: a) Health Sciences, for example for representation of organs or acquisition of manual skills: chemistry labs; anatomy atlas; dental morphology, and more; b) Engineering, e.g.: building design and planning; virtual engineering laboratories; simulation of engineering techniques; and 3) Humanities, e.g: (1) Second language learning in context; (2) Historical sites tours [19]. Those uses have been varied, such as to introduce students to (1) procedural-practical knowledge (filling out a report or extinguishing fires); (2) for declarative knowledge (learning names of planets or theoretical concepts in pneumatics); (3) and for developing analytical and problem-solving skills (diagnosing patients or learning to code) [14].

Enabling this potential in a widespread manner, for the worldwide community of instructors and learners, requires elements of instructional design, to ensure the practicality and quality of instruction. It is described as the art of creating detailed specifications that allow the development, evaluation, and maintenance of learning situations [19]–[21], supporting needs analysis, goal setting, evaluative goal setting, and specific learning outcomes, [7]–[9], [19], [21], [22]. Instructional design is thus of great importance because it is through this that instructors develop guidance on how to develop and optimize the learning process in a feasible, quality-based approach [23], [24].

III. METHODOLOGY

To identify the guidance available on effectively implementing Immersive Virtual Reality in Online Higher Education pedagogy, we set to identify models of Instructional Design that have been applied with this educational technology context. A systematic review [25] was conducted to identify such, along with their phases and characteristics. The systematic review protocol, in view of application to educational sciences and computer science, follows Kitchemham et al. [25], which is commonly used in this field. It has seven elements: (1) Objective; (2) PICOC (Population, Intervention, Comparison, Outcome, Context); (3) Research questions; (4) Keywords and Synonyms; (5) Search String; (6) Source; and (7) Selection Criteria.

A. Objective

We aim to identify instructional design models for immersive virtual reality environments in online higher education with their phases and characteristics.

B. PICOC (Population, Intervention, Comparison Outcome, Context)

TABLE I. PICOC

PICOC	
Population	Students or instructors in degree-granting programs.
Intervention	Instructional design with immersive VR
Comparison	Characteristics of the immersive VR instructional models
Outcome	Instructional design models for VR
Context	Online Higher Education

C. Research questions

- What are the instructional design models for immersive virtual reality?
- What phases do instructional design models contemplate?
- What are the characteristics of the immersive instructional design models?

D. Keywords and Synonyms

TABLE II. PICOC

Keyword	Synonyms
Instructional models	Learning design models, instructional design, instructional frameworks, pedagogical design, pedagogical frameworks, pedagogical models
Online degree-granting courses	Distance learning, University, e-learning, online learning
Immersion	VR, immersive, virtual reality

E. Search String

("Online degree courses" OR "Distance learning" OR "University" OR "e-learning" OR "online learning") AND ("immersion" OR "VR" OR "immersive" OR "virtual reality") AND ("Instructional models" OR "Learning design models" OR "instructional design" OR "instructional frameworks" OR "pedagogical design" OR "pedagogical frameworks" OR "pedagogical models").

F. Source

The selected database was Scopus (http://www.scopus.com) for its expressiveness at an international level and its self-worth at an academic level.

G. Selection Criteria

Inclusion Criteria:

- Instructional models description for the application of Virtual reality in online higher education.

Exclusion Criteria:

- Application of immersive virtual reality without instructional model description.
- Augmented reality, not virtual reality.
- Language the research team is not proficient with.
- Not applied in Online Higher Education.
- Not spatially immersive virtual reality (non-headset).
- No mention of an instructional design model.
- The full version of the paper is not available.
- Not applied in classes using immersive virtual reality.

A total of 197 studies were retrieved from the Scopus database. Nine were duplicates. The remaining 188 studies were selected by title, abstract and short read according to the eligibility criteria (presented in the Selection Criteria section). After screening, 170 studies were excluded for various reasons – mostly for not being with immersive virtual reality. The remaining 18 publications underwent a full-text evaluation, with only 4 articles having reached the extraction phase. The process is presented in the flowchart (Fig.1.).

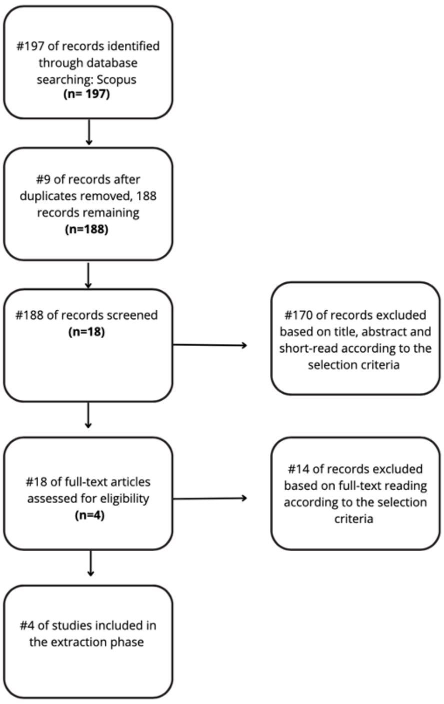


Fig. 1. Flow of literature search

From the final articles corpus, it is noticeable that the largest group of exclusion was of articles that were not based on using immersive VR headsets (126 exclusions). This was followed by publications that were in the context of Online Higher Education (16 exclusions).

For Data Extraction, we followed these extraction questions:

- RQ1 Which instructional design model for immersive VR is used in the paper?
- RQ2 Which instructional design models for immersive VR are mentioned in the background section of the paper?
- RQ3 Which phases of instructional design models for immersive VR are mentioned in the article's background section?
- RQ4 Which phases of instructional design models for immersive VR is used in the paper?
- RQ5 What are the characteristics of the model? What theoretical concepts is it based on?

For the data analysis, a content analysis was carried out that focused on two main parts: the definition of the characteristics of the models aimed at verifying the context of the model's emergence and whether it was based on other models previously developed for other contexts, and the phases, i.e. all the elements that described the steps that the authors used in the conception of Instructional Design, as well as suggestions and guidelines.

Those elements were used to analyze the identified VR Instructional Design models regarding the standards of the Association for Educational Communications & Technology [12], [13]. This analysis enabled us to identify eventual qualitative gaps in those Instructional Design Models for Immersive Virtual Reality.

IV. Results

For data analysis, thematic content analysis was carried out. Four Instructional Design models for Immersive Virtual Reality were identified from the survey process: (1) XR ABC Framework [26]; (2) iVR Learning (M-iVR-L) Framework [27]; (3) TESLA Instructional Design Model [24]; (4) Castronovo et al. Design Model [28]. In this section, these models are summarized using the descriptive framework, including their characteristics and phases.

H. XR ABC Framework by Shippee and Lubinsky (2021) [26]

Characteristics of the model:

XR ABC Framework provides a common approach and language for designing, developing, and describing learning experiences to the use of VR.

Phases of the instructional design model:

Absorb: This stage involves an absorbing experience. In this stage it is expected the use of several immersive tools with the objective of sustaining experiences of comprehension and recollection.

Blend: In this stage, with the use of pre-existing resources for VR, it is expected to instill in the student new ways of learning, with the objective of taking them to apply, analyze and evaluate the content.

Create: In this stage learning moments and experiences arise that allow the creation of new content. This aims to demonstrate understanding of the content by building unique objects that did not previously exist within VR applications.

This stage allows learners to use creativity to demonstrate actual learning and understanding. Learners become owners of the learning and creators of content.

I. *iVR Learning (M-iVR-L) Framework by Mulders, Buchner and Kerres (2020) [27]*

Characteristics of the model:

Based on the Cognitive Theory of Multimedia Learning, a framework was developed with six recommendations support the learning process with Immersive Virtual Reality.

Phases of the instructional design model:

Learning first, immersion second: It is recommended to manage the use of immersive resources to prioritize the learning process over immersion. Immersion (here considered only in a spatial sense, not in a cognitive absorption sense) is used only as much as necessary to achieve learning objectives.

Segment complex tasks into smaller units: It is recommended to segment the content into different sessions to avoid overloading the students and to aid learning management and acquisition.

Provide learning relevant interactions: It is recommended to avoid unnecessary interactions that are irrelevant to learning; allow for pre-training of students, not only in terms of basic concepts but also on how to use the interactive tools.

Guide immersive learning: It is recommended to invest in guidance during use of Immersive Virtual Reality, to provide moments of learning acquisition without the increased load provided by the tool becoming an impediment to it.

Build on existing knowledge: It is recommended to use prior knowledge of the student to introduce new concepts and tools such as VR. This strategy will allow management of learning difficulty and verification of the students' level of knowledge and the support they need.

Provide constructive learning activities: It is recommended to provide constructive learning activities that allow the knowledge of learning to be built and applied to new problem-based tasks, inside or outside of Immersive VR.

J. *TESLA Instructional Design Model by Fragkaki, Hatzligeroydis, Palkova and Kovas (2019) [24]*

Characteristics of the model:

This model was based on three other Instructional Design models. The ASSURE model took the role of the base model. The TPACK model was integrated in the fourth step of the ASSURE model [Utilize Technology and Resources] and the Kirkpatrick model was integrated in the last step of the ASSURE model [Analyzing and Evaluating].

Phases of the instructional design model:

TESLA ASSURE

Analyze Learners: In this stage of the model, the authors focus on distinguishing and knowing the needs, knowledge, skills, and attitudes of the learners.

State Standards and Objectives: Defining the goals to be achieved by the learners with instruction.

Select Strategies, Technology and Resources: Selecting the strategies, technology, and resources.

Use Technology and Resources: Plan how resources will be used in a way that contributes to the acquisition of the goals. In this planning phase the TPACK model was inserted as an additional element of critical thinking. This model is described in three primary forms of knowledge: Content Knowledge, Pedagogical Knowledge, and Technological Knowledge. Based on the application scenario described in the article, Content Knowledge focuses on students' perceived knowledge about the topic of VR learning scenarios; Technological Knowledge concerns knowledge about specific ways of thinking and acting with VR, tools, and resources; and Pedagogical Knowledge concerns students' in-depth knowledge of the theoretical, conceptual, and methodological framework that pedagogically supports VR content. This general type of knowledge applies to understanding why learners learn, what they learn, and how they can use it. It is about learner learning, general classroom management skills, lesson planning, and types of student assessment.

Require Learner Participation: Plan how to actively involve learners.

Evaluate and Revise: In this step the evaluation of the teaching-learning process is prioritized. This includes training strategies and the technology, media and materials used. To support this, they selected the Kirkpatrick model. This model contains four levels, the first relating to evaluation of student reaction or satisfaction; the second level relating to evaluation of learning, understanding how students have acquired the knowledge or skills; the third level is behavioral assessment, in which changes in behavior are verified; and the fourth levels is outcome assessment, to determine whether the learning objectives have been met.

K. *Castronovo et al. Design Model (2019) [28].*

Characteristics of the model:

The model by Castronovo et al. is based on the ADDIE Instructional Design model.

Phases of the instructional design model:

Analysis: In this phase the target audience and the context are first identified. In a second moment the learning objectives are defined.

Design: Definition of the components to be used in the instruction. Definition of the components of game creation: mechanics, story, technology, and aesthetics.

Development: Putting into practice the created elements and the defined learning objectives. Creation of the game.

Implementation and evaluation: The phases of implementation and evaluation were not described in the application of the model to the context.

V. ANALYSIS

Based on the Association for Educational Communications & Technology [12], [13] standards verification of their presence in the Instructional Design models for Immersive Virtual Reality studies was performed.

L. *XR ABC Framework*

XR ABC Framework model described by three steps [Absorb; Blend; Create], is limited in its description. One only finds reference to the standard Assumptions through the reference in the Absorb stage to recollection moments to take into account previous learning and students' previous knowledge; to the Activities and Resources standards, in the Blend stage with the introduction of different tools with the aim of broadening experiences; and finally the application proposed in the Create stage in which the student is given the opportunity to create their own resources.

M. iVR Learning (M-iVR-L) Framework

The iVR Learning (M-iVR-L) Framework presents itself as a set of recommendations that aim to play a relevant role in the design of an instructional plan, especially in the context of the scarce presence of guiding elements.

It is possible to find reference to resources in the recommendations for "Learning first, immersion second", in which emphasis is given to the management of the use of immersive resources to prioritize the learning process over immersion; and in the recommendation "Provide learning relevant interactions" in which importance is given to the pre-training of students, not only in terms of basic concepts but also on how to use the interactive tools.

As for the standardization of activities, this is visible in the recommendation to "Segment complex tasks into smaller units", in which importance is given in this context to dividing tasks to lessen the students' overload and to aid the management and acquisition of learning.

Promotion of orientation also has great prominence in the recommendation "Guide immersive learning", in the sense of helping the student in the environment and in the management of learning in this context, in which the load is higher. In addition, the Assumption standard also has recommendations for connecting to prior learning. This is found in the recommendation to "Build on existing knowledge."

In these recommendations, one finds references to the standard application in the recommendation "Provide constructive learning activities" which recommends carrying out constructive learning activities that allow the construction of the knowledge of learning and its application to new tasks based on problems, inside or outside the Immersive VR, to enhance the opportunity to apply learning.

N. TESLA Instructional Design Model

The TESLA model is a composition of three models, starting with the ASSURE model, promoting a cross-linking of data and the reinforcement of components such as reflection and critical thinking through the TPACK model, and assessment through the Kirkpatrick model.

The ASSURE model focus on standards as the purpose through the Analyze Learners and State Standards and Objectives, which promote the establishment of goals and objectives, as well as the study of learners and their relationship with the content; the standard of the resources in which there is a focus on Selecting strategies, technology, and resources, as well as planning how the resources will be used to contribute to the acquisition of the objectives. In this same section, Use Technology and Resources, the TPACK model is introduced, which in addition to introducing elements of critical reflection that relate to the reflection standard, introduces relevance to technological knowledge that concerns knowledge about specific ways of thinking and acting, in this case with VR.

Finally, evaluation standard are the "Evaluate and Revise" step with the introduction of Kirkpatrick's evaluation model.

O. Castronovo et al. Design Model

Castronovo et al Design Model is presented as an approach to using the ADDIE Instructional Design model for teaching in Immersive Virtual Reality. In the case presented, only three of the five steps of the model were applied.

In this contextual application of the model, it is only possible to verify the presence of the purpose with the use of the students' analysis and the structuring of the objectives; the resources with the design and structuring of the materials to be used in learning; and the application in the development when putting the activities into practice.

VI. Discussion

It was noticeable that considering the standards of the Association for Educational Communications & Technology, none of the models under study addressed all of them. Standards such as continuous/formative assessment, that is, the promotion of feedback, the sequencing of activities, the use of independent learning, and how to promote assessment, all are gaps in the studied models. Among those, it is perceptible that the recommendations proposed in the iVR Learning (M-iVR-L) Framework are the most descriptive and specific to the context under study: instruction in Virtual Reality. Their recommendations address issues such as the need to segment the classes, to provide guides throughout the sessions, and the previous introduction to the tool, among others for better reflection on the context and to help in the preparation of the classes.

The use of models not originally developed for the context under study proved to be vague regarding their examples and the needs faced when planning classes for immersive Virtual Reality, as is the case of Castronovo et al. Design Model.

On the other hand, from the models studied it is possible to observe that two distinct groups emerges as to the recommendations they present. On the one hand, the XR ABC Framework and the iVR Learning (M-iVR-L) Framework, especially the latter, introduce contextual elements of the application of Virtual Reality in teaching, such as the need for segmentation of sessions to avoid overload, prior exploration of the tool given the experimentation of different resources, the promotion of follow-up moments among others. On the other hand, the application of traditional models created for another context allows reflection about the importance in these same contexts, of clearly defining the objectives considering the target audience, of planning, and of structuring how the resource will be used in what context and for what purpose, of selecting strategies and of outlining an evaluation plan.

VII. Conclusions

This systematic review sought to identify instructional models used in online higher education with immersive learning environments based on virtual reality headsets, such as Oculus, HTC, or others. We identified four models of instructional design for immersive Virtual Reality and analyzed them, finding that they are based on Instructional Design models developed for other contexts, especially traditional models such as ADDIE.

Of the four models, two groups stand out: those that present suggestions for the VR context and were developed specifically for the VR context; and those that were applied to the VR context but had been developed in a generic instructional design context. The XR ABC Framework and the iVR Learning (M-iVR-L) Framework comprise the former group, presenting recommendations related to the use of VR: segmenting tasks, managing immersion time, and providing pre-instruction contact experiences with the tool. The latter group consists of the TESLA model and the Castronovo el al. model. Being more generic, they recall the importance of creating objectives directed to the target audience, considering the elements of evaluation, and defining the use of the resources and the purpose, among other aspects.

The iVR Learning Framework (M-iVR-L) Framework stands out as the most complete supporting element for the design of classes in Virtual Reality. But even so, it does not include all the standards of the Association for Educational Communications & Technology [13], [14] (AECT). It does present relevant elements about the context that allow a reflection on the elements to be considered when preparing a session for Immersive Virtual Reality, such as the need for task segmentation due to the increased load resulting from the use of the tool.

Thus, future research seeking to develop instructional models for VR may consider setting forth from M-iVR-L to address all standards of AECT, but also to combine the aspects of learning design concerns that more generic models have kept and are less present in current VR-specific models.

Acknowledgment

This work was funded by the European Commission, under project REVEALING – REalisation of Virtual rEAlity LearnING environments (VRLEs) for Higher Education – Erasmus+ / Cooperation Partnerships 2021-1-DE01-KA220-HED-000032098. We also extend our thanks to all collaborators and partners involved.

D. Pedrosa expresses gratitude to the Foundation for Science and Technology (FCT) and CIDTFF for their support under the Scientific Employment Stimulus 2017, within the framework of project CEECIND/00986/2017, as well as project UID/CED/00194/2020.

References

[1] A. Gutiérrez-Martín and K. Tyner, "Educación para los medios, alfabetización mediática y competencia digital," *Comunicar: Revista Científica de Comunicación y Educación*, vol. 19, no. 38, pp. 31–39, 2012, doi: 10.3916/C38-2012-02-03.

[2] J. Ferrés and A. Piscitelli, "La competencia mediática: propuesta articulada de dimensiones e indicadores," *Comunicar: Revista Científica de Comunicación y Educación*, vol. 19, no. 38, pp. 75–82, 2012, doi: 10.3916/C38-2012-02-08.

[3] L. Morgado, "Ambientes de aprendizagem imersivos," *Immersive learning environments*, pp. 102–116, Dec. 2022, doi: 10.18817/vjshr.v1i2.32.

[4] W. Chen, "Collaboration in Multi-user Immersive Virtual Environment," phdthesis, Université Paris Saclay (COmUE), 2015. Accessed: Apr. 14, 2023. [Online]. Available: https://theses.hal.science/tel-01340364

[5] P. Reddy, B. Sharma, and K. Chaudhary, "Digital Literacy: A Review of Literature," *IJT*, vol. 11, no. 2, pp. 65–94, Jul. 2020, doi: 10.4018/IJT.20200701.oa1.

[6] A. Ferrari, "DIGCOMP: A Framework for Developing and Understanding Digital Competence in Europe.," JRC Publications Repository. Accessed: Mar. 30, 2022. [Online]. Available: https://publications.jrc.ec.europa.eu/repository/handle/JRC83167

[7] M. R. Hanifa and H. B. Santoso, "Evaluation and recommendations for the instructional design and user interface design of coursera MOOC platform," in *2019 International Conference on Advanced Computer Science and information Systems (ICACSIS)*, IEEE, 2019, pp. 417–424.

[8] M. Molenda, C. M. Reigeluth, and L. M. Nelson, "Instructional Design," in *Encyclopedia of Cognitive Science*, L. Nadel, Ed., Nature Publishing Group, 2003.

[9] G. R. Morrison, S. M. Ross, J. E. Kemp, and H. Kalman, "Designing Effective Instruction John Wiley & Sons," *Inc., United States*, 2011.

[10] V.-V. I. G. KL, "Paradigms in the theory and practice of education and training design," *Educational Technology Research and Development*, vol. 52, no. 2, p. 69, 2004.

[11] W. Dick, "The Dick and Carey Model: Will It Survive the Decade?," *Educational Technology Research and Development*, vol. 44, no. 3, pp. 55–63, 1996.

[12] A. A. Piña, "Instructional design standards for distance learning," *Bloomington: Association for Educational Communications and Technology*, 2017.

[13] A. A. Piña, "AECT Instructional Design Standards for Distance Learning," *TechTrends*, vol. 62, no. 3, pp. 305–307, May 2018, doi: 10.1007/s11528-018-0282-9.

[14] J. Radianti, T. A. Majchrzak, J. Fromm, and I. Wohlgenannt, "A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda," *Computers & Education*, vol. 147, p. 103778, Apr. 2020, doi: 10.1016/j.compedu.2019.103778.

[15] Á. Antón-Sancho, D. Vergara-Rodríguez, D. G. Calatayud, and P. Fernández-Arias, "Virtual Reality as a Teaching Resource in Higher Education: Professors' Assessment," in *Pervasive Computing and Social Networking*, G. Ranganathan, R. Bestak, and X. Fernando, Eds., in Lecture Notes in Networks and Systems. Singapore: Springer Nature, 2023, pp. 139–149. doi: 10.1007/978-981-19-2840-6_11.

[16] A. F. Di Natale, C. Repetto, G. Riva, and D. Villani, "Immersive virtual reality in K-12 and higher education: A 10-year systematic review of empirical research," *British Journal of Educational Technology*, vol. 51, no. 6, pp. 2006–2033, 2020.

[17] M. J. Maas and J. M. Hughes, "Virtual, augmented and mixed reality in K–12 education: a review of the literature," *Technology, Pedagogy and Education*, vol. 29, no. 2, pp. 231–249, Mar. 2020, doi: 10.1080/1475939X.2020.1737210.

[18] D. Vergara, Á. Antón-Sancho, J. Extremera, and P. Fernández-Arias, "Assessment of Virtual Reality as a Didactic Resource in Higher Education," *Sustainability*, vol. 13, no. 22, Art. no. 22, Jan. 2021, doi: 10.3390/su132212730.

[19] A. Nichols Hess and K. Greer, "Designing for Engagement: Using the ADDIE Model to Integrate High-Impact Practices into an Online Information Literacy Course," *Communications in Information Literacy*, vol. 10, no. 2, Dec. 2016, doi: 10.15760/comminfolit.2016.10.2.27.

[20] R. M. Branch, *Instructional Design: The ADDIE Approach*. Boston, MA: Springer US, 2009. doi: 10.1007/978-0-387-09506-6.

[21] K. L. Gustafson and R. M. Branch, "What is instructional design? Trends and Issues in Instructional Design and Technology," *Saddle River, NJ: Merrill/Prentice Hall*, 2002.

[22] I. Visscher-Voerman and K. L. Gustafson, "Paradigms in the theory and practice of education and training design," *ETR&D*, vol. 52, no. 2, pp. 69–89, Jun. 2004, doi: 10.1007/BF02504840.

[23] A. Arslan, "Instructional Design Considerations for Flipped Classroom," *International Journal of Progressive Education*, vol. 16, no. 6, pp. 33–59, Dec. 2020, doi: 10.29329/ijpe.2020.280.3.

[24] M. Fragkaki, I. Hatzligeroydis, Z. Palkova, and K. Kovas, "Instructional Design in Virtual Reality Environments: The case of Palestinian HEIs," in *10th International Conference on Information, Intelligence, Systems and Applications, IISA 2019*, Institute of Electrical and Electronics Engineers Inc., 2019. doi: 10.1109/IISA.2019.8900765.

[25] B. Kitchenham, "Procedures for performing systematic reviews," *Keele, UK, Keele University*, vol. 33, no. 2004, pp. 1–26, 2004.

[26] M. Shippee and J. Lubinsky, "Training and Learning in Virtual Reality: Designing for Consistent, Replicable, and Scalable Solutions," in *International Conference on Electrical, Computer, and Energy Technologies, ICECET 2021*, Institute of Electrical and Electronics Engineers Inc., 2021. doi: 10.1109/ICECET52533.2021.9698487.

[27] M. Mulders, J. Buchner, and M. Kerres, "Virtual Reality in Vocational Training: A Study Demonstrating the Potential of a VR-based Vehicle Painting Simulator for Skills Acquisition in Apprenticeship Training," *Technology, Knowledge and Learning*, 2022, doi: 10.1007/s10758-022-09630-w.

[28] F. Castronovo *et al.*, “Design and development of a virtual reality educational game for architectural and construction reviews,” in *ASEE Annual Conference and Exposition, Conference Proceedings*, American Society for Engineering Education, 2019. [Online]. Available: https://www.scopus.com/inward/record.uri?eid=2-s2.0-85078720216&partnerID=40&md5=54dcf061fbbd27dd550dcc7773c6b73b

FORMAÇÃO DOCENTE NA UNIVERSIDADE FEDERAL DO ABC DURANTE A PANDEMIA DO COVID 2019: RESULTADOS, DESAFIOS E PERSPECTIVAS FUTURAS

Teacher training at the Federal University of ABC during the Covid 2019 pandemic: Results, Challenges and Future Perspectives

Carolina Correa de Carvalho
Centro de Modelagem Engenharia e Ciências Aplicadas (CECS)
Universidade Federal do ABC (UFABC)
São Bernardo do Campo, SP, Brasil
carolina.carvalho@ufabc.edu.br

Carla Lopes Rodriguez
Centro de Matemática, Computação e Cognição (CMCC)
Universidade Federal do ABC (UFABC)
Santo André, SP, Brasil
c.rodriguez@ufabc.edu.br

Marcella dos Santos Abreu
Centro de Ciências Humanas e Letras (CCHL)
Universidade Federal do Piauí (UFPI)
Teresina, PI, Brasil
marcella.abreu@ufpi.edu.br

***Resumo*— Este artigo apresenta a experiência formativa Planejamento de Cursos Virtuais (PCV), que foi realizada em 2020, na Universidade Federal do ABC (UFABC), instituição de ensino superior pública instalada na região do ABC paulista (Brasil). O objetivo da ação foi responder às demandas institucionais no contexto emergencial da pandemia de COVID-19, frente às necessidades de suspensão das atividades acadêmicas e a urgência de integrar as tecnologias digitais no processo de ensino-aprendizagem. A abordagem metodológica do curso priorizou o envolvimento de equipe multidisciplinar no planejamento, na elaboração, na realização e no acompanhamento de ações colaborativas mediadas em formato remoto. Dentre os resultados obtidos da formação, destaca-se o alcance de 30% dos professores da UFABC, que se aproximaram de práticas dialógicas na educação online, com perspectivas de impacto na continuidade do seu trabalho docente, conforme relatos de participantes apresentados na avaliação do processo.**

Palavras-chave*— *Ensino Superior, Formação docente, Tecnologias educativas, Covid-19

***Abstract*—This article presents the formative experience of Virtual Course Planning (VCP), which took place in 2020 at the Federal University of ABC (UFABC), a public higher education institution located in the ABC region of São Paulo, Brazil. The objective of this initiative was to address institutional demands in the emergent context of the COVID-19 pandemic, in response to the need for suspension of academic activities and the urgency to integrate digital technologies into the teaching-learning process. The methodological approach of the course prioritized the involvement of a multidisciplinary team in the planning, development, implementation, and monitoring of collaborative actions mediated in a remote format. Among the results obtained from the training, it is worth highlighting the engagement of 30% of UFABC teachers who approached dialogical practices in online education, with potential impacts on the continuity of their teaching work, as reported by participants in the evaluation of the process.**

Keywords*— *Higher Education, Teacher Training, Educational Technologies, Covid-19.

I. INTRODUÇÃO

Nas últimas décadas, as Instituições de Ensino Superior (IES) têm sido desafiadas a criar, inovar e construir novas formas de ensinar, com a finalidade de atender as demandas do mundo do trabalho, em constante transformação no século XXI. Alguns fatos, como o rápido desenvolvimento tecnológico, a digitalização, a automação, a robótica, a internet das coisas e a inteligência artificial, juntamente com as alterações climáticas, provocaram mudanças estruturais significativas e continuarão a acelerar o processo de criação de novos empregos e de alteração ou mesmo desaparecimento de outros.

A educação, especialmente o ensino superior, tem sido interpelada a responder a esses desafios apresentados aos seus estudantes quanto ao permanente desenvolvimento de habilidades que, ao longo da vida, permita-lhes, além de gerir seu percurso profissional, desenvolver a consciência da necessidade de equilíbrio entre sustentabilidade social, econômica e ambiental [1]. Dado o papel fundamental dos docentes nesse processo [2], é crucial investir em sua formação continuada e na cultura colaborativa de inovação dentro das IES, para uma atuação eficaz e equitativa.

Crises globais, como a Covid-19, trouxeram de uma só vez, às IES a urgência de reorganizar suas ofertas de cursos, fomentando entre seus professores e estudantes a competência digital. De fato, em 2020, o ensino superior foi posto à prova, fazendo com que as atividades presenciais migrassem rapidamente para ambientes virtuais. Na América Latina, essa transformação trouxe à tona os currículos e as práticas de ensino tradicionais das instituições de ensino superior, pois poucas delas tinham modelos sólidos de ensino a distância antes da pandemia.

A rápida transferência do presencial para o virtual permitiu uma resposta imediata, mas inutilizou o potencial da interação virtual e das atividades de aprendizagem [3]. A maioria dos professores não foi capacitada para oferecer cursos a distância, ou tampouco possuía a tecnologia necessária para o ensino, dificultando a criação de um ambiente interativo e eficaz na sala de aula online. O papel da gestão educacional é crucial na mudança pedagógica [4] e, para tanto, necessita do apoio de estruturas nesse processo, de modo a envolver diferentes atores e a sustentar as transformações desenvolvidas na IES.

Uma das primeiras necessidades nesse contexto é traçar estratégias para a formação continuada dos professores do ensino superior para atender as demandas e desafios do cenário global aqui já apresentado. Masetto e Gaeta (2015) [5] em sua pesquisa fazem uma revisão sobre a trajetória pedagógica universitária e da formação de professores no Brasil, demonstrando que, no início de 1960, o debate epistemológico e didático sobre a docência no ensino superior brasileiro era praticamente inexistente. Com o passar do tempo, apesar de mudanças, com inovações sendo incorporadas e até criando-se espaços para estudos, pesquisas e publicações relacionadas às práticas pedagógicas, ainda se faz necessário desenvolver programas de formação para renovação de práticas tradicionais de docência, compartilhamento de novos métodos e recursos que favoreçam a aprendizagem e o desenvolvimento de habilidades para selecionar abordagens didáticas e aplicá- las adequadamente.

Como resposta a esses anseios, a experiência a ser aqui relatada compreende a contextualização de formação de professores de ensino superior em tecnologias educativas e de metodologias ativas em contexto pandêmico, seguidas das estratégias de implementação, da avaliação do percurso formativo e de considerações finais.

II. Contextualização Geral Da Formação PCV 2020

A. Curso Equipe e Temática

O curso de formação docente Planejamento de Cursos Virtuais (PCV), que ocorreu entre 03 de agosto e 20 de setembro de 2020, sob a coordenação do Núcleo Educacional de Tecnologias e Línguas (NETEL), da Universidade Federal do ABC (UFABC), foi uma ação emergencial, que teve como objetivo principal capacitar os docentes para atuarem no ensino remoto, modalidade estabelecida para dar continuidade às aulas, dada a necessidade de suspensão das atividades acadêmicas presenciais ocorrida em meio à pandemia da COVID-19.

Para concepção e implantação do curso foram mobilizadas 54 pessoas de diferentes categorias da instituição: servidores docentes (7), técnicos administrativos (12), trabalhadores terceirizados (2), estudantes de graduação (4) e pós-graduação (24), estagiários (1), que compuseram uma equipe multidisciplinar e se envolveram em várias frentes de trabalho, desde o planejamento, execução e coordenação, até a gestão e avaliação da ação. A equipe multidisciplinar foi o diferencial de todo o processo formativo e, para tal, foi organizada em grupos focais com responsabilidades e atuação diferentes e, ao mesmo tempo, conectadas durante o processo.

Tendo como público-alvo o corpo docente da UFABC, o PCV 2020 se inseriu no período que antecedeu o início do primeiro período letivo planejado para o atendimento da crise pandêmica, intitulado Quadrimestre Suplementar (QS). A atividade formativa respondeu à previsão explicitada no artigo 9º, de normativa institucional elaborada exclusivamente para o QS [6], a qual versava, entre outras temáticas, sobre a necessidade de formação docente. O produto desse processo deveria ser a elaboração de um mapa de atividades, para entrega à Direção do Centro e à Coordenação de Curso de vinculação como parte do plano de ensino da disciplina virtual pela qual cada docente seria responsável no período subsequente.

Embora parcialmente baseado em ações de formação que o NETEL já desenvolvia até então, o PCV 2020 foi concebido especificamente para o contexto da pandemia de Covid-19 e da decorrente suspensão das atividades presenciais da comunidade acadêmica. A formação compreendeu 60 horas, distribuídas em sete semanas e foi oferecida totalmente online, no Ambiente Virtual de Aprendizagem (AVA) Moodle. O curso teve como objetivo promover a reflexão e o debate a respeito da educação mediada por tecnologias, por meio do compartilhamento de conteúdo, recursos e métodos para o planejamento de cursos/disciplinas virtuais, bem como para a autoria de materiais didáticos para o ensino híbrido, semipresencial, remoto e/ou educação online. Como resultados, esperava-se que os participantes se apropriassem dos elementos necessários para elaborar uma proposta de curso virtual e ampliassem a compreensão sobre fatores relevantes relacionados ao desenho de um curso/disciplina mediado por tecnologias. A evidência de aprendizado culminou com a produção de um mapa de atividades.

Para cumprir tal propósito, o PCV contemplou atividades, em sua maioria, assíncronas, bem como encontros síncronos semanais, no formato de webinários, que contaram com convidados internos e externos à UFABC. No caso dos convidados externos, foram cinco instituições: Instituto Alberto Luiz Coimbra de Pós-Graduação e Pesquisa de Engenharia, da Universidade Federal do Rio de Janeiro (COPPE-UFRJ); Instituto Federal do Mato Grosso do Sul (IFMS), Universidade Federal do Estado do Rio de Janeiro (UNIRIO); Universidade Federal Rural do Pernambuco (UFRPE); Instituto Federal do Espírito Santo (IFES).

As temáticas abordadas no PCV 2020 envolveram reflexões sobre: i) ensino remoto, educação online, ensino híbrido e Educação a Distância; ii) análise e design de um curso/disciplina virtual; iii) conceitos sobre aspectos didático-pedagógicos que envolvem o planejamento de um curso/disciplina virtual; iv) elaboração do Mapa de Atividades; v) conceitos básicos sobre licenças e direitos autorais, Recursos Educacionais Abertos (REA) e acessibilidade em materiais digitais; vi) metodologias ativas, atividades síncronas e assíncronas no processo de ensino- aprendizagem; vii) tipos de acompanhamento (feedback) e métodos para avaliação da aprendizagem (rubricas, avaliação por pares, autoavaliação); viii) validação do projeto de curso planejado no Mapa de Atividades, por meio da implementação de todo (ou de parte) do que foi planejado no Ambiente Virtual de Aprendizagem (AVA) Moodle.

Por meio de atividades individuais e colaborativas, a proposta era que os participantes refletissem e vivenciassem estratégias de ensino-aprendizagem online, interagindo com mediadores e colegas do curso, culminando em uma construção coletiva de saberes. Além disso, o percurso de aprendizagem traçado no PCV 2020 foi estruturado de maneira a conduzir os participantes à elaboração do seu projeto de curso/disciplina virtual.

A mediação foi realizada por docentes e pós-graduandos que orientavam e realizavam feedback das atividades semanalmente. A avaliação foi contínua, realizada de acordo com a participação, entrega das tarefas propostas e conclusão do mapa de atividades. Tiveram direito à certificação os participantes que cumpriram 75% do curso.

Considerando a implicação de diferentes atores no processo de concepção e desenvolvimento do PCV 2020, a seção Avaliação do percurso formativo apresenta a análise das respostas coletadas, por meio de dois formulários avaliativos, ambos aplicados ao término do curso. O primeiro foi encaminhado a participantes da formação e, o segundo, a professores, pós-graduandos tutores, graduandos da equipe de apoio e servidores especialistas em educação da UFABC que compuseram a equipe multidisciplinar envolvida na adaptação, aprimoramento e desenvolvimento da ação.

B. *Perfil dos Participantes*

Inscreveram-se para o PCV 2020 421 pessoas. A motivação inicial desses participantes inscritos foi registrada em formulário de inscrição que gerou a representação em uma nuvem de palavras, na qual se destacam a expectativa e a necessidade de aprender suscitadas entre os respondentes com predominância de termos que sugerem capacitação, aprendizado, necessidade, atualização, conhecimento, ferramentas, conforme Fig. 1.

FIGURA 1: Nuvem de palavras PCV 2020

O perfil da turma foi identificado por meio de formulário respondido por 328 participantes ao longo da primeira semana de curso. A turma foi constituída por 50,3% de pessoas que se autodeclararam do gênero masculino e de 49,1% do gênero feminino.

Ressalta-se que, no universo dos docentes da UFABC, apenas 34% se declaram de gênero feminino, o que aponta uma participação proporcionalmente maior de mulheres.

Com relação à idade dos respondentes (Fig. 2), é relevante observar o amplo espectro de representação do grupo, ainda que a maior parte se concentre na faixa etária entre 40 e 49 anos.

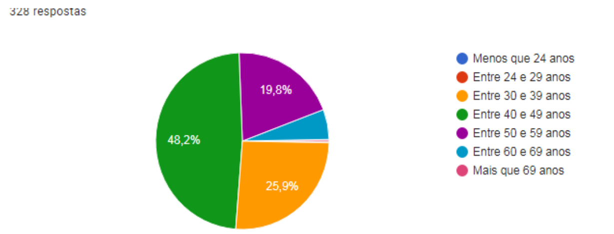


FIGURA 2: Distribuição dos participantes por faixa etária PCV 2020

É importante ressaltar que, além de docentes da UFABC (308 respondentes), havia participantes com outros vínculos institucionais: Tutor UAB e de cursos de especialização (13); Professor convidado e/ou colaborador-visitante (5) e discentes de pós-graduação (2).

No que se refere a experiências anteriores no campo da educação online, a maioria declara ter atuado em período anterior à implementação do QS na UFABC, intitulado Ensino Continuado Emergencial – ECE. Outras vivências em cursos online, seja como estudantes, docentes ou tutores também são apontadas, como é possível verificar no gráfico da Fig. 3.

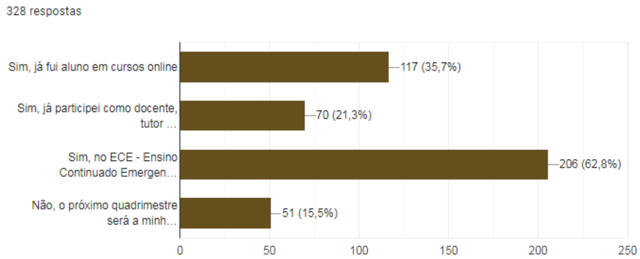


FIGURA 3: Experiência dos participantes com educação online PCV 2020

Ainda vale apontar que, para aproximadamente 58% dos participantes, o PCV se constituiu como o primeiro curso de formação relacionado à educação online em sua carreira.

III. Estratégias Metodológicas Para A Integração Das Metodologias Na Prática

O percurso formativo do PCV 2020 foi organizado em sete semanas, com uma dedicação média de oito horas semanais. As aulas e atividades foram ofertadas majoritariamente de forma assíncrona, contando ainda com sete webinários, sendo quatro síncronos, por meio dos quais foi possível interagir sobre o conteúdo de cada módulo, as estratégias e as ferramentas digitais para apoio ao processo de ensino- aprendizagem. As temáticas propostas para a formação foram:

i) ambientação, ii) busca de ideias, iii) planejar o Mapa, iv) organizar o conteúdo, v) praticar e comparar, vi) implantar e avaliar, vii) encerramento.

A cada semana as atividades eram abertas às terças-feiras e ficavam disponíveis até às segundas-feiras subsequentes. As semanas foram organizadas com objetivos de aprendizagem específicos, bem como atividades e webinários alinhados a eles. O participante era convidado a refletir sobre o tema da semana e a interagir com seus pares para desenvolver a atividade proposta. Por ser um curso mediado, os tutores foram fundamentais, engajando e motivando os participantes, personalizando e individualizando a aprendizagem de acordo com a necessidade deles. Às/aos participantes era recomendado observarem o tempo de dedicação para entrega dentro do prazo semanal para receberem a devolutiva de suas produções em até 72 horas após o fechamento das atividades. A organização das temáticas semanais, bem como alguns artefatos elaborados durante o percurso, seguiram as etapas sugeridas na metodologia de design instrucional ADDIE [7].

A. *Semana 1: Ambientação*

A primeira semana teve como proposta o envolvimento do participante na ambientação no AVA Moodle-UFABC e o acolhimento ao curso realizado pela coordenação, professores e tutores. Os participantes exploraram a dinâmica do curso, conheceram a turma e iniciaram as reflexões sobre ensino remoto, educação online, ensino híbrido e educação a distância. Além disso, foram convidados a participar do webinário inaugural síncrono, evento transmitido ao vivo pelo Youtube.

B. *Semana 2: Busca de Idéias*

A segunda semana propôs uma reflexão sobre temas relacionados à análise e ao design de um curso/disciplina virtual, por meio de reflexão sobre o projeto pedagógico da UFABC e de cursos específicos aos quais os participantes estavam vinculados. Como atividade prática, foi proposto o início do planejamento do projeto de curso/disciplina, a partir do preenchimento do documento chamado briefing, com a finalidade de promover reflexões importantes sobre perfil do público-alvo, tipo de organização do curso pretendido, área do conhecimento, quantidade de alunos atendidos e carga horária. O webinário da semana 2 trouxe o tema dos desafios do projeto pedagógico da UFABC no ensino remoto.

C. *Semana 3: Planejar o Mapa*

A terceira semana teve como objetivo principal explorar os temas, subtemas e os respectivos objetivos de aprendizagem para o projeto de curso/disciplina do participante, de acordo com a Taxonomia de Bloom [8]. Para apoiar o planejamento e a organização de conteúdos, atividades, recursos e formas de avaliação, foi proposto o artefato Mapa de Atividades, um instrumento bastante usado no design instrucional de cursos virtuais. O webinário teve como tema “Elaborando objetivos de aprendizagem para sua disciplina online”. O objetivo desse encontro foi ampliar as reflexões sobre a temática da semana 3, envolvendo, principalmente, as discussões acerca da elaboração de objetivos de aprendizagem para a disciplina online. O tema do webinário foi proposto como apoio para a atividade de preenchimento do Mapa de Atividades.

D. *Semana 4: Organizar o Conteúdo*

A quarta semana abordou questões que envolvem interação, colaboração e diálogo em aulas síncronas e assíncronas. Foram apresentados e discutidos os conceitos básicos que envolvem a elaboração e a curadoria de conteúdos e materiais para cursos virtuais. Com relação à seleção de materiais didáticos, temas como licenças e direitos autorais, Recursos Educacionais Abertos (REA) [9] e acessibilidade foram apresentados e colocados em discussão. Como atividade, foi proposta a seleção e organização criteriosa dos materiais que apoiariam o conteúdo do projeto de curso/disciplina elaborado pelos participantes, tendo como base as reflexões sobre os aspectos inclusivos, éticos e legais a serem considerados nos recursos para aulas síncronas e assíncronas que pretendiam incluir no Mapa de Atividades. O webinário teve como tema “Dinamizando a sua aula online: participação, interatividade, conversação, colaboração e co- autoria”. O objetivo do encontro foi ampliar as reflexões sobre a temática da semana 4, envolvendo, principalmente, as discussões sobre o espaço-tempo das aulas síncronas e assíncronas, bem como suas possibilidades de interação.

E. *Semana 5: Praticar e Comparar*

Na quinta semana, foram apresentadas algumas metodologias ativas e os aspectos que envolvem atividades colaborativas e trabalho em grupo no processo de aprendizagem, bem como quais são suas implicações no desenvolvimento de um curso/disciplina para educação online/ensino remoto. As possibilidades de interação e diálogo em momentos síncronos e assíncronos foram exploradas. Foram propostas duas atividades: a primeira envolveu a colaboração em grupos e a segunda relacionada ao planejamento das atividades práticas do próprio projeto do participante tendo como base as reflexões sobre o uso de metodologias ativas para aulas síncronas e assíncronas que poderiam incluir no seu Mapa de Atividades. O webinário desta semana 5 teve como tema relatos de experiências e práticas ativas no ensino remoto na UFABC.

F. *Semana 6: Implementar e Avaliar*

A sexta semana deu continuidade ao tema da semana anterior e explorou os tipos de feedback, estratégias de comunicação e avaliação da aprendizagem. Também foram apresentados alguns AVAs e foi sugerida a implementação do todo (ou de parte) do projeto de curso/disciplina planejado no Mapa de Atividades em um AVA de escolha do participante. Como atividade final do planejamento do curso/disciplina, foi proposto o preenchimento da linha de feedback, comunicação e avaliação para cada período definido no seu Mapa de Atividades. Na sexta semana o webinário teve como tema “Avaliação da aprendizagem: exemplos e práticas no ensino online”. O objetivo deste encontro foi refletir sobre a avaliação da aprendizagem no ensino online, incluindo quais ferramentas e estratégias podem dar suporte a esse processo e auxiliar os participantes a continuarem o preenchimento do Mapa de Atividades

G. *Semana 7: Encerramento*

A sétima semana foi dedicada ao encerramento do curso e foi realizada no formato de “workshop virtual”, em formatos assíncrono e síncrono, envolvendo o compartilhamento do que foi desenvolvido no curso, projetos finais das disciplinas, bem como a autoavaliação do percurso. O último webinário foi na modalidade síncrona com o tema “Workshop virtual de compartilhamento e encerramento do PCV 2020”. Como palestrantes, envolveram-se na preparação e no desenvolvimento dessa atividade dez participantes do PCV que foram convidados a apresentar o mapa de atividades construído durante o curso, a evidência de sua aprendizagem durante o PCV. O evento foi realizado na plataforma Google Meet, com acompanhamento síncrono de 40 pessoas.

Vale reiterar que a entrega do Mapa de atividades foi o ponto alto do processo de avaliação contínua, realizada por meio de atividades propostas semanalmente, cuja entrega foi acompanhada pelos tutores e docentes do curso. Nesse sentido, os mapas de atividade elaborados pelos participantes representam a concretização dos objetivos alcançados no percurso formativo realizado no PCV 2020

IV. Avaliação da Formação PCV 2020

A formação contou com 421 inscritos. Ao final do processe 238 participantes foram aprovados, 148 reprovados e 41 desistentes. Para aprovação, foi necessário o cumprimento de 75% das atividades previstas. Tendo como base os dados estatísticos da instituição disponíveis até o momento da oferta do curso (797 docentes) [10], o número de aprovados (238) representou aproximadamente 30% do corpo docente da UFABC e, se considerarmos o número de inscritos (421), e dos que tiveram acesso ao conteúdo (382), 47% do corpo docente da instituição (Fig. 4).

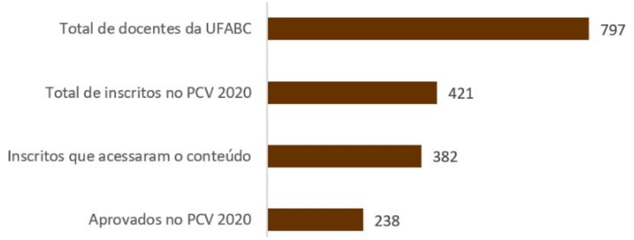


FIGURA 4: Alcance da formação PCV 2020

Ao final da ação foram recebidas 214 respostas ao formulário de avaliação, elaborado com questões abertas e fechadas. Para as questões fechadas, foi utilizada a escala Likert de 1 a 5.

A avaliação da formação PCV 2020 foi realizada sob a ótica do participante com o objetivo de entender como foi a sua experiência ao longo das sete semanas, e também a avaliação sob a ótica da equipe multidisciplinar ao mediar este percurso.

A. Auto Avaliação Dos Participantes Sobre Sua Experiencia Na Formação PCV

Usando a escala likert de 1 (nenhum empenho) a 5 (empenho muito alto), foram gerados dados que demonstram elevado nível de engajamento no curso entre os respondentes: 19% dos respondentes avaliaram o seu empenho como muito alto (escala 5), aproximadamente 49% dos participantes apontaram a escala 4, 29% escala 3, 3% escala 2 e 0% escala 1, mostrando um alto porcentual de empenho entre os respondentes.

Também foram convidados a autoavaliar tal engajamento ao longo da trajetória, em tarefas gerais e específicas, tais como a elaboração do mapa de atividades e os webinários: 28% dos participantes se envolveram em todas as atividades da formação, 57% atestam o engajamento em todas as propostas referentes à elaboração do mapa de atividades além das participações nos webinários. Outros 12% realizaram apenas as atividades obrigatórias referentes ao mapa de atividades, 3% entraram esporadicamente sem realizar as atividades propostas, e nenhum dos respondentes atentou que não conseguiu se engajar no processo (Fig. 5).

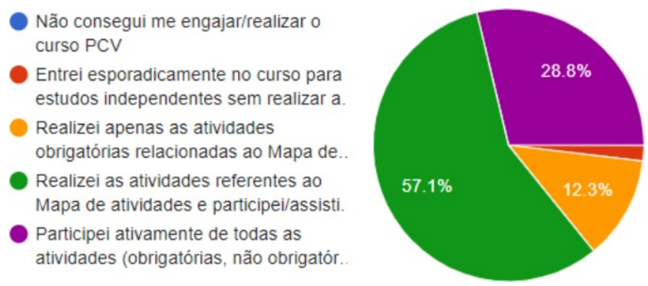


FIGURA 5: Engajamento nas atividades do curso PCV 2020

Estes números demonstram que 97% dos participantes atingiram o objetivo principal da formação: desenvolver o seu mapa de atividades para o planejamento de suas atividades remotas durante o QS.

No que tange ao desenvolvimento desse documento, apenas 1% declara não ter conseguido concluí-lo. Aproximadamente 86% afirmam ter conseguido elaborá-lo de forma completa, tendo em vista a disciplina a ser ministrada no quadrimestre suplementar, 13% dos respondentes atestam que conseguiram elaborar o mapa parcialmente (Fig. 6).

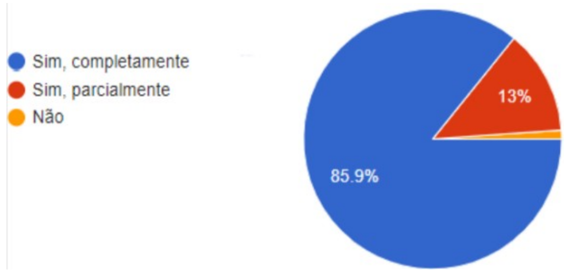


FIGURA 6: Elaboração do Mapa de Atividades PCV 2020

Sobre a capacidade de criar um curso virtual a partir das temáticas abordadas no PCV 2020 – outro objetivo da formação –, aproximadamente 54% avaliaram que se encontravam nesse patamar. A autoavaliação foi realizada mediante a relação entre tal potencialidade dos participantes e a taxonomia de Bloom, utilizando escalas da taxonomia através de verbos “Lembrar, Entender, Aplicar, Analisar, Avaliar e Criar” que representam os níveis dos objetivos de aprendizagem indo do nível cognitivo mais baixo ao nível mais complexo. Os resultados dessa questão mostraram que aproximadamente 70% dos respondentes atingiram as três escalas mais elevadas da taxonomia.

A formação se baseou em teorias construtivistas, propondo atividades colaborativas para motivar o compartilhamento de ideias, aprendizados e experiências entre seus pares. Uma questão neste escopo mostrou que mais de 77% dos respondentes conseguiram de alguma forma compartilhar e aprender com seus pares. Apesar dessa resposta, a questão seguinte procurou entender com quem foi estabelecida essa interação, apontando que a comunicação foi facilitada entre tutores, sendo, entretanto, menos frequente entre colegas, coordenadores e professores do PCV.

Uma questão sobre os feedbacks e mediação ao longo do percurso mostrou a importância desta interação para a construção do mapa de atividades e cumprimento dos objetivos de aprendizagem ao longo do percurso, já que aproximadamente 66% apontaram tal relevância.

Com relação à satisfação com a formação e o seu impacto em práticas didático-pedagógicas, a avaliação mostrou que a maior parte dos respondentes se dividiram entre os níveis 3, 4 e 5 da escala likert (mais de 93% dos respondentes). Os respondentes também avaliaram, de modo geral, como forte e positivo a repercussão que o curso poderia causar sobre suas práticas didático-pedagógicas, sobretudo nas modalidades remoto/online, semipresencial e híbrido (Fig. 7). Esse fator corrobora, portanto, a importância da formação continuada nas práticas pedagógicas dos professores do ensino superior [5].

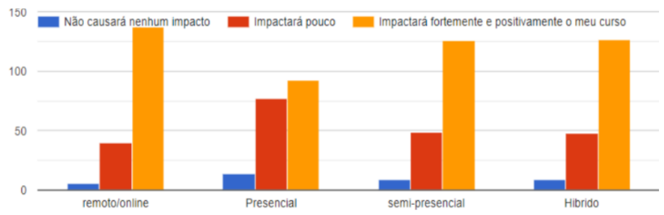


Figura 7: Impacto nas práticas didáticas pós curso PCV 2020

Foram realizadas questões abertas para entender mais profundamente os i) resultados de aprendizagem mais significativos, ii) os desafios para a implantação do curso/disciplina no quadrimestre suplementar e iii) anseio de formações futuras. Foram obtidas 184 respostas e de sua leitura foram destacados comentários representativos de temáticas recorrentes apontadas pelos respondentes.

Acerca dos resultados mais significativos de aprendizagem do PCV 2020 é possível destacar a ênfase dada às ferramentas digitais exploradas (ou a serem ainda exploradas em outras formações). Essa constatação destaca a predominância do tema avaliação e planejamento na educação online - este representado por meio da expressão nos mapas de atividades elaborados. Outros comentários sobre o resultado ilustram a possível incorporação dessas temáticas em suas práticas, demonstrando que alguns professores não sabiam como planejar e estruturar um curso online, tampouco reconheciam a importância do mapa de atividade e o potencial das atividades colaborativas.

Houve também manifestações sobre o alinhamento dos objetivos do curso, a carga horária e a sugestão de repensar atividades e avaliações para o desenvolvimento de competências, colocando o professor no papel de mediador e valorizando o participante na construção do seu aprendizado. Outra devolutiva evidencia a importância do planejamento e de tempo para a preparação do conteúdo e da escolha de ferramentas que irão apoiar o percurso, além da necessidade da construção de oportunidades de diálogos no ambiente virtual, o reconhecimento do mapa de atividade como peça chave para o planejamento, a relevância dos direitos autorais e materiais abertos na construção do conteúdo, da questão de inclusão e acessibilidade e da importância de se ter um Ambiente Virtual de Aprendizagem (AVA) para organizar todo este percurso.

Com relação aos desafios, o domínio de ferramentas ressurge como central, juntamente com as expectativas sobre o engajamento dos estudantes no processo. Quanto a formações futuras vislumbradas pelos respondentes para a melhoria de suas práticas no ensino online, presencial e/ou híbrido, a recorrência da palavra Moodle coloca mais uma vez em evidência o anseio já explicitado pelo conhecimento sobre ferramentas e plataformas na educação online.

Complementando estas questões, alguns comentários recorrentes foram deixados ao final do formulário mostrando que, além de elogios e sugestões, há críticas que se referem, mais uma vez, às expectativas de um grupo sobre a abordagem de ferramentas digitais para aplicação em suas aulas durante o quadrimestre suplementar. Algumas manifestações pontuais de participantes com a expectativa de saber usar ferramentas mostraram a possibilidade de incompreensão de uma parte dos inscritos sobre os objetivos do PCV.

Outros comentários evidenciaram que a abordagem de conteúdos relacionados às práticas didático-pedagógicas foi fundamental ao enfrentamento dos desafios do ensino remoto – e para além dele, demonstrando a importância de uma formação continuada que busca preencher a lacuna de preparação docente para o ensino superior [5].

B. *Percepção da Equipe Multidisciplinar Mediando a Formação PCV*

Um formulário de avaliação também foi apresentado à equipe do PCV formada por tutores (estudantes de pós-graduação da UFABC), professores, equipe multidisciplinar (servidores docentes e técnico-administrativos especialistas em educação) e equipe Classroom (estudantes de graduação inseridos em projeto de extensão).

De modo geral, o nível de satisfação entre esse grupo de respondentes foi alto, 65% apontando escala likert 5 como muito satisfeitos 30%, escala 4, 5% escala 3 e 0% de escala 1 e 2, como é possível observar no gráfico da Fig. 8.

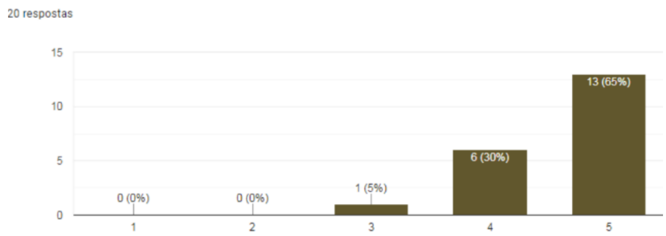


FIGURA 8: Nível de satisfação da equipe PCV 2020

Dentre 24 tutores, 12 responderam à avaliação, destacando como pontos positivos para sua atuação o apoio e o acompanhamento da coordenação do curso em todo o processo. Como aspectos negativos, é evidenciada a dificuldade de comunicação, de organização do tempo e de entendimento de alguns participantes sobre os objetivos da formação. A colaboração entre a equipe e a coordenação foi também apontada como positiva por três dos quatro professores do curso. Nesse pequeno grupo, também ressoou a sugestão de oferta de oficinas sobre ferramentas digitais, sobretudo para produção de videoaulas.

Cinco dentre os nove servidores da equipe multidisciplinar destacaram como positiva a integração de diferentes profissionais da universidade nesse trabalho. Dentre as dificuldades encontradas, é importante a constatação sobre o acúmulo de atividades institucionais no período, o que teria inviabilizado maior dedicação desse grupo no processo. Da equipe do NETEL, houve duas respostas, com destaque à avaliação positiva sobre a atuação dos tutores no PCV. O acúmulo de funções e de horas dedicadas ao curso – para além da jornada, inclusive, foram pontos negativos explicitados. Dois estudantes de graduação do grupo Classroom, que atuaram na elaboração de tutoriais para o uso de ferramentas digitais inseridos no curso, avaliaram como positivo o apoio da equipe e, como negativos, a falta de conhecimento sobre alguns conteúdos, bem como os prazos incipientes para a execução de suas tarefas.

V. Considerações Finais

O objetivo deste artigo foi apontar o PCV 2020 como um exemplo de experiência de formação docente na pandemia como resposta a um contexto emergencial e, ao mesmo tempo, aos anseios de transformação das práticas de ensino-aprendizagem no ensino superior.

O curso PCV 2020 se destaca por ser uma formação que ocorreu em 2020, em um momento de pandemia mundial da Covid 19, possibilitando aos docentes da UFABC refletirem sobre suas práticas docentes, planejarem e construírem uma proposta para o quadrimestre subsequente, a partir de um processo formativo que trouxe temas como projeto pedagógico, atividades e ferramentas para trabalho colaborativo, o mapa de atividades como instrumento de planejamento para o alinhamento dos objetivos de aprendizagem e possibilidades de reorganizar atividades e avaliações para construção de um processo de ensino-aprendizagem online mais eficiente.

O projeto também se destacou por ser uma formação com mediação de uma equipe multidisciplinar, motivando discussões e aprendizados com os pares, promovendo o diálogo e o acolhimento em um momento crítico vivenciado por todas as pessoas frente à pandemia mundial. Diante de angústias referentes à continuidade das atividades acadêmicas, especificamente utilizando o ensino online, a formação PCV 2020 se destacou pelo alto engajamento do corpo docente que participou da ação tendo uma representatividade de aproximadamente 30% dos docentes da instituição.

A avaliação da formação PCV mostrou que a grande parte dos participantes considerou positiva a formação, destacando o mapa de atividades como instrumento de grande importância para o planejamento de um curso online. Ainda destacaram que o curso conseguiu impactá-los como docentes, podendo trazer transformações para o ensino presencial, híbrido e online. Apontaram preocupações futuras com relação a desenvolverem habilidades para estruturação de seus cursos/disciplinas no AVA Moodle e o uso de ferramentas digitais em processos de ensino-aprendizagem. A avaliação revelou ainda a disposição e vontade para realizar novas formações que os apoiem na modernização do ensino com tecnologias.

A avaliação da equipe Multidisciplinar destacou a comunicação como desafio neste tipo de formação, bem como necessidade de apoio institucional para gerenciarem o tempo de envolvimento com outras atividades. Foi apontada, especialmente, a urgência de uma estratégia e infraestrutura da gestão da Universidade que incentive e apoie os professores nesta transformação continuada do ensino.

Com base nas sugestões apontadas nas avaliações dos participantes e da equipe multidisciplinar do PCV, são apresentadas recomendações para futuros desdobramentos da oferta desta edição da formação que antecedeu o Quadrimestre Suplementar de 2020. No que se refere aos desafios da comunicação do curso, sugere-se a formação de grupos menores para cada tutor, diminuindo o distanciamento entre esse ator e os seus participantes. Com relação à organização do tempo, seria desejável a distribuição do conteúdo em mais semanas, e que a formação não ocorra durante o recesso dos docentes.

O entendimento sobre os objetivos do PCV deve ser permanentemente retomado, assim como deve haver um canal para escuta sobre as necessidades de outras oficinas e cursos que atendam outras demandas dos docentes - inclusive no campo do uso de ferramentas digitais. Com relação à atualização de todos os membros da equipe quanto ao repertório teórico sobre educação online, houve uma indicação sobre a criação e manutenção de uma base de dados com autores e grupos de pesquisa da área, tanto do Brasil quanto do exterior.

Quanto ao apoio à equipe multidisciplinar para oferta de novas formações, pontua-se como importante nesse processo a continuidade do envolvimento de especialistas em educação da UFABC que se encontram entre docentes e técnicos administrativos (técnicos em assuntos educacionais e/ou pedagogos). A institucionalização dessas parcerias pode ampliar as possibilidades de oferta de futuras capacitações, tendo aqueles servidores especialistas também como professores e proponentes dos cursos.

Espera-se que essa experiência possa inspirar outros modelos mediados de formação docente no ensino superior, para o enfrentamento dos desafios educacionais, profissionais e climáticos do século XXI, que, como já destacamos, vêm sendo gestados antes da pandemia e seguem emergentes na retomada de nossas atividades presenciais, sem qualquer reflexão e efetiva transformação.

REFERENCIAS

[1] UNDP Digital Identity Management Framework, https://undp.sharepoint.com/teams/collaborationtoolbox/SitePages/IDAM_Launch_webinars-26_October_2021.aspx. Accessed 12/11/2021.

[2] OECD, The state of higher education: One year in to the COVID-19 pandemic. Paris: OECD Publishing, 2021 https://dx.doi.org/10.1787/83c41957-en.

[3] J. J. Walcutt, S. Schatz (Eds). Modernizing Learning: Building the Future Learning Ecosystem. Washington, DC: Government Publishing Office, 2019.

[4] E. Ryymin, T. Lilja, P. Tuominen, N. Niskanen, M. Corporan, J. R. Crousset, "Finnish-Dominican Education Programme for Managers Developing Competences for Industry 4.0", unpublished.

[5] M.T. Masetto e C. Gaeta. Trajetória da pedagogia universitária e formação de professores para o ensino superior no Brasil. Em Aberto, Brasília, v. 32, n. 106, set/dez 2015, p. 45-57.

[6] UFABC. "Resolução nº 240/2020 – CONSEPE". in Boletim de Serviço nº 963. Santo André, 2020, p. 6-20.

[7] J. Braga [org]. Objetos de aprendizagem: Introdução e fundamentos. Santo André, Editora da UFABC, 2014.

[8] A. D. Krathwohl, P. A. Kathleen, C. R. E. Mayer, P. P. James Raths, M. C. Wittrock. A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives Complete. New York, NY: Longman 2001.

[9] EDUCAÇÃO ABERTA. Recursos Educacionais Abertos (REA): Um caderno para professores. Campinas, 2013.

UFABC. UFABC em Números 2019. https://propladi.ufabc.edu.br/images/ufabc_numeros/ufabc_numeros_ref2019.pdf Accessed 23/09/2023.

E-CAMPUS: CONCEPT AND DESIGN OF A VIRTUAL CAMPUS TO SUPPORT DISTANCE LEARNING IN A POLYTECHNIC INSTITUTE

Ana Loureiro
School of Education – Polytechnic Institute of Santarém
Santarém, Portugal
LE@D – Universidade Aberta
Lisboa, Portugal
https://orcid.org/0000-0003-1322-3070

Inês Messias
School of Education – Polytechnic Institute of Santarém
Santarém, Portugal
LE@D – Universidade Aberta
Lisboa, Portugal
https://orcid.org/0000-0003-4771-6455

Dina Rocha
School of Education – Polytechnic Institute of Santarém
Santarém, Portugal
https://orcid.org/0000-0003-4798-4812

***Abstract*— The decision to conceive, design, develop and implement a virtual campus in a Higher Education Institution (HEI) stems from the desire to open up and share our training offer with a wider public, while at the same time responding to national and international demands. The team of the Distance Learning axis of the *#eCapacitar* project designed and developed the proposal of this virtual campus, called *e-Campus*. It was conceived and designed in the light of the *Pedagogical Model for Distance Learning*, also designed by the same team. In order to familiarise the teaching staff with good teaching practices (face-to-face, online and hybrid) in aspects such as learning environments, pedagogical planning or assessment, the development of this virtual campus was based on the reports prepared by the *Portuguese National Agency for Assessment and Accreditation of Higher Education* (A3ES). The *e-Campus* will integrate different areas that will allow distance students to have access to all the essential features for an effective and successful learning and monitoring of the courses. This paper presents the stages of development of this virtual campus, explaining all the steps taken to implement it, all the areas that make it up, as well as the future plans for its continuous development and improvement.**

Keywords*— *e-Learning, Virtual campus, Distance learning, Higher education, Development model, #eCapacitar

I. INTRODUCTION

Distance learning, according with the *Portuguese National Agency for Assessment and Accreditation of Higher Education* (A3ES) [1], refers to learning that is predominantly delivered with physical separation between the participants in the educational process, namely teachers and students, where:

- interaction and participation are technologically mediated and supported by online academic and technological support teams;
- The curricular design is oriented to allow access without limits of time and place to the contents, processes and contexts of teaching and learning;
- The pedagogical model is specially designed for teaching and learning in virtual environments.

In that sense, distance learning programmes [1] must have a set of material and technological means, including a virtual campus with pedagogical interaction functionalities, permanently accessible to all participants in the educational process, in particular teachers and students, and complying with information security requirements, as well as a student-oriented website that ensures permanent access to digital libraries, repositories, digital material lending services and virtual laboratories, connected to an integrated academic management system that ensures the dematerialised processing of all academic processes.

In this paper we will describe the virtual campus, called *e-Campus*, conceived by the #eCapacitar project team (DL axis). This virtual campus will support and sustain, from a technological point of view, the pedagogical model for distance learning and teaching of the *Polytechnic Institute of Santarém* (IPSantarém).

II. BACKGROUND AND THEORETICAL FRAMEWORK

The virtual campus arises from the need felt in the IPSantarém to provide distance learning programmes, in order to innovate and diversify its training offer, thus reaching different audiences. Back in 2015, IPSantarém published the *Regulation of Functioning, Attendance and Evaluation of E-learning Courses of the School of Education* [2], assuming distance learning (DL) as a strategy for the diversification of its training offer the focus on training processes in e-learning/b-learning format. However, and due to the lack of regulation at national level for this matter, the training offer of fully distance-learning courses has not experienced marked developments. In fact, it was only in 2019 that the government approved the legal framework for distance higher education, through *Decree-Law no. 133/2019 of 3 September* [1]. According with it, distance learning should be seen as a high-quality alternative to face-to-face learning and not merely a reproduction or parallel of it. The flexibility of time and place offered by distance learning ensures that students can develop their educational pathway at the pace that best matches their personal and professional lives. It is also important to note that technologically mediated teaching and learning has experienced a marked expansion in Portugal, as part of the response of Higher Education Institutions (HEIs) to the pandemic crisis, so the A3ES issues the *Administrative Order 16/2022*, with criteria for the evaluation of proposals for study programmes with non-face-to-face teaching components [3].

Given the national context, we can then perceive, in the *Strategic Plan 2019-2022 of IPSantarém* (in Axes 1, 4 and 5, based on actions 6, 8 and 11), a continuity regarding the maintenance and reinforcement of institutional strategies to develop distance education in the HEI [4]. It should also be noted that the SAMA *#eCapacitar project - Empowering for digital inclusion in IPSantarém's business areas*, approved by the *Administrative Modernisation Agency* (AMA) and funded by COMPETE, has been the main driver, among other axes, of the DL axis in HEI. It is also essential that IPSantarém meets the *Strategic Plan 2021-2024* issued in 2022 by A3ES, namely with regard to the new challenges for HEIs and the generalisation of distance learning that includes pedagogical mechanisms, methodologies, resources, timetables and monitoring and evaluation systems different from the face-to-face modality [5].

In this sense, it became crucial to formalise, in IPSantarém, a support unit for the implementation of distance education, as well as the definition of a pedagogical model suitable for distance learning and the design and development of a virtual campus. The study programmes taught at a distance must have, cumulatively, certain material and technological means, which include a virtual campus with pedagogical interaction functionalities, permanently accessible to all participants in the educational process, especially teachers and students, and complying with information security requirements; as well as a student-oriented website that ensures permanent access to digital libraries, repositories, digital materials lending services and virtual laboratories; that is connected to an integrated academic management system that ensures the dematerialised processing of all academic processes [1].

Thus, in order to respond to the aforementioned Decree Law [1], the team of the DL axis of the #eCapacitar project conceived and developed the proposal for a virtual campus, called *e-Campus*. This virtual campus will support and sustain, from a technological point of view, the *Pedagogical Model for Distance Learning*, also designed by the same team. The *Pedagogical Model for Distance Learning* of IPSantarém [6] was designed to promote the acquisition of knowledge and the development of skills for meaningful and transformative learning by students, taking into account the advantages, characteristics and potentials of online education. The success of an e-learning system involves a systematic process of planning, designing, evaluating and implementing online learning environments where learning is actively encouraged and supported [7]. Therefore, the aim to develop a solid, meaningful virtual campus, to respond to the call to open up the institutional academic offer, started with the understatement of national and international strategies and goals, as well as the knowledge of already existing best practices of distance learning models [8, 9, 10, 11] and virtual campuses [12, 13, 14, 15, 16].

III. DESIGN OF THE *E-CAMPUS*

IPSantarém's distance learning offer will be delivered through online platforms and with the use of different digital tools and applications, in e-learning and b-learning modalities. Although distance learning is a broad and evolving field, with different perspectives and approaches to its definition, all emphasise the use of technology to facilitate learning and the potential of e-learning to provide flexible, accessible, engaging and space- and time-independent learning experiences. Having that in mind, the virtual campus was grounded on certain foundations and principles considered essential by the development team: Quality and Learning Experience; Digital Inclusion and Accessibility; Ubiquity and Flexibility; Interaction; Open Science and Environmental Sustainability; Ethic and Academic Integrity [6]. The design of a virtual campus raises issues of pedagogy and how the design of physical and virtual spaces differs. When designing a virtual learning environment, we think about how to present lecture notes and assignments online, and how to develop a learning environment in which students can access learning materials and interact with peers and teachers. The focus is as much on the interaction between students and teachers in a virtual place as it is on the information provided.

The quality, and therefore the effectiveness, of a virtual campus has, in itself, an impact on the quality of student learning in distance education. In order to guarantee this quality, the virtual campus has been designed according to several models and approaches to the instructional design.

The *Rapid Prototyping* model [17], commonly used in software engineering, we believe is a viable model for instructional design, particularly for computer-based instruction, given the similarities between software design and instructional design. Rapid prototyping requires a design environment that makes it practical to quickly synthesise and modify instructional artefacts. In order for prototyping to be efficient and effective, a number of prerequisites are needed, such as certain types of media and the availability of tools (mainly computer software) that offer modularity and plasticity.

The ADDIE approach "describes a process applied to instructional design in order to generate episodes of intentional learning" [18]. Briefly, the stages of the model are: analysing for the purpose of identifying the possible causes of a performance gap; designing for the purpose of verifying the desired performances and the appropriate testing procedures; developing for the purpose of generating and validating the learning resources required during the life of the learning units; implementing for the purpose of preparing the learning environment and engaging the students; evaluating for the purpose of assessing the quality of the learning products and processes, both before and after implementation.

The *Conditions of Learning Theory* [19] specify a sequence of nine events that enhances the learning process and promotes effective teaching, providing a framework for designing and delivering instruction in a structured and systematic manner. The focus of the theory is on intellectual skills, although Gagne's theoretical framework covers all aspects of learning. In its original version, particular attention was given to military training environments. The theory has had applications in the instructional design in all fields.

Therefore, concerning the campus design, the first step was to collect and then analyse the needs of the potential users of the campus (students and teachers). This was followed by exploratory research into other existing campuses to understand the choices made in terms of layout, structure, navigation and functionality, as well as the range of interaction elements available to users. That is, after the conception and design by the pedagogical instructional design team, the moments of development and implementation of the campus by the technical team will be followed by the evaluation of its effectiveness for distance teaching and learning. Each of these moments is carried out in a systematic way, identifying options for improving the effectiveness of the resource whenever it is verified that this is necessary.

Given the foundations of this model, its application is not limited to the design of the campus, but also to the Open Educational Resources (OER) that will be designed and developed, as well as to the courses and curricular units that will be implemented based on innovative pedagogical practices.

In an attempt to represent the design model adaptation used, a representative diagram of the steps and considerations that allowed the development and implementation of the *e-Campus* is presented here. (Fig. 1).

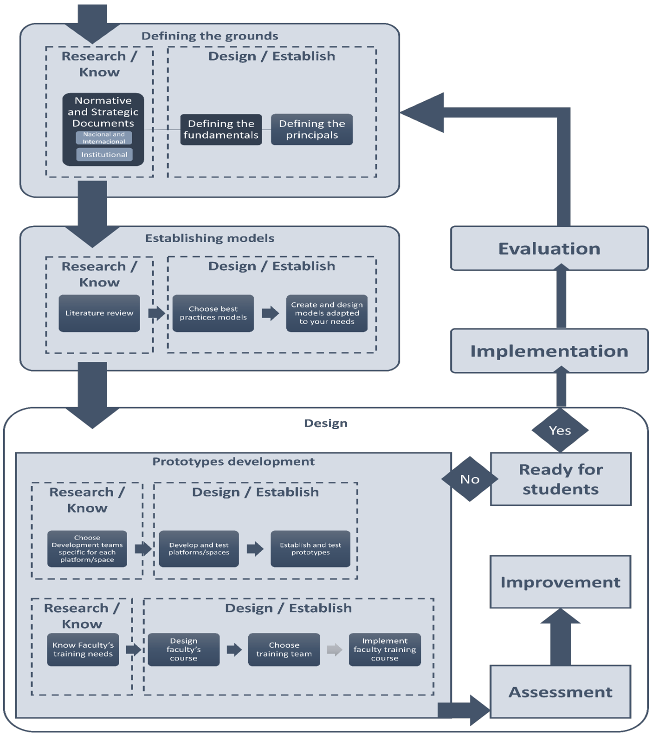


Fig. 1. IPSantarém's virtual campus design model

IV. Interface of the *e-Campus*

Virtual campus applies advanced information technology and tools to realise digitisation from environment (like equipment and classrooms), resources (like books and lectures), activities (like management and services). In order to expand the functions of the traditional campus and improve its efficiency, it builds a digital space based on the traditional campus to extend the time and space dimension of the real campus. Therefore, the *e-Campus* will integrate different spaces that will allow distance learning students to have access to all the essential functionalities for an effective and successful follow-up of the courses. It has been decided to give these spaces a name (acronym) that is universal and easy to understand and recognise by both national and international students (and teachers). The *e-Campus* will provide the following spaces: online teaching and learning (e-Learn); initiation and ambience (e-Welcome); interaction and socialisation (e-Lounge); training and capacity building (e-Train); videoconferencing (e-Meet); digital educational applications and tools (e-Tools); scientific information management (e-InfoHub); technical support (e-Help); as well as access to the academic portal and other university services. The following is a description of the different spaces that form the interface of the IPSantarém virtual campus

1) e-Learn: Teachers and students have at their disposal an online teaching and learning space, developed from the LMS Moodle, where they can access all the study programmes in force at IPSantarém. In addition to the tools for designing activities and learning resources of Moodle itself, there will also be available (among others that can be integrated): tools that allow teachers to create interactive digital educational resources; an evaluation and testing system and a statistical analysis system (qualitative and quantitative).

2) e-Meet: The videoconferencing system integrated in the IPSantarém *e-Campus* is the one that has been officially adopted by the institution to date, through a protocol established with the FCCN, which allows the use of other tools in addition to the Colibri Zoom, such as the Videocast video streaming service and the Filesender file sending service. The online videoconferencing system can be accessed by direct dialing so that students can attend scheduled meetings, either as part of the courses they are attending or for meetings with teaching staff.

3) e-InfoHub: The scientific information management space of IPSantarém is an interface that aggregates several platforms of scientific information resources, integrating, to date, the Scientific Repository of the Institution (RCIPS), the Institute's Library Portal, B-on, RCAAP, EBSCO, Arquivo.pt and Educast. It is also planned to integrate the Digital Base of Knowledge (DBK) and other services that may arise in the context of scientific information management. We highlight the DBK because this platform will provide all the Open Digital Educational Resources (OER) that have been, are or will be developed in IPSantarém. Furthermore, teachers and students will be able to receive customised online training on the resources available in the field, by appointment.

4) e-Welcome: This will be the first space that students of IPSantarém's distance learning courses will visit. Here, the whole process of initiating and setting up the use of not only the Moodle LMS (e-learning space), but also all the other spaces of the IPSantarém Virtual Campus will be carried out. The aim is to anticipate any doubts or technical difficulties that could jeopardise the smooth running of teaching and learning activities. The tutorials and user guides of Moodle and of the spaces that are part of the *e-Campus* and the specific tools to be used during the courses will be available here. Initially, for a more structured environment, this space will be supported by mentors (students with more than one enrolment) who will accompany the new students, guiding them in the first steps of using the Campus and helping them to clarify any doubts that may arise (in a peer mentoring logic). This space, designed and developed by the Distance Learning Unit team, includes various activities designed to encourage interaction between students and teachers, with the technological interface and with the content. The initiation and development of the space is dynamised by the course coordinators in partnership with the mentors. This space has the following goals:

- Introduce students to the virtual campus environment;
- Promote socialisation between students;
- Promote socialisation between students and course coordinators;
- To develop students' technical skills in the use of the main tools available in the different spaces of the virtual campus and to make them aware of the

importance of good time management in online distance learning;

- Present the rules and standards for online communication and interaction.

e-Lounge: In order to develop class and community spirit and to promote group cohesion, a space for online interaction and socialisation is provided. In DL environments it is essential for student motivation and involvement to create a sense of belonging to the learning community, where peer-to-peer dialogue exists beyond the moments provided by the learning activities. Thus, it is intended that students have an immersive three-dimensional place (virtual world / metaverse) where they can interact and socialise, where the exchange of knowledge and experiences is autonomous and active. To support synchronous lecturing and collaborative learning, the virtual world will provide different spaces such as a shared student campus, collaborative zones, lecture rooms and lounge areas. It will also be equipped with support tools to enable navigation between multimedia content for students and teachers. Moodle plug-ins could be developed and integrated to enhance the environment with LMS services in a natural way. This 3D world could be used to increase the interaction and communication opportunities between teachers and students, and between students themselves, especially to encourage planned and unplanned social encounters. Virtual worlds allow for first-person learning, for experiencing and learning (through text and voice chat; role-playing; simulations; emulations; presentations), and thus for building knowledge more effectively, making them an alternative way of presenting content, and thus of capturing and holding students' attention [20]. Virtual worlds, as immersive environments, support flexible learning as online sessions can be set up at a time and (virtual) place that is free from restrictions and can be adapted, allowing for more effective student participation. Nevertheless, the opportunity offered by the technological revolution needs to be explored in order to achieve a simple, low-cost setup immersive environment that is affordable for everyday use.

5) e-Train: In this space, it is intended to offer training courses of different types, with different topics and with the aim of empowering different target groups (students, faculty; internal and external to the IPSantarém community), in order to promote lifelong learning, allowing the (re)qualification and recycling of skills. These courses can be, for example, MOOCs, micro-credits, short courses, among others. In fact, as for the concern of faculty in the immediate aftermath of the COVID-19 pandemic, UNESCO [21] presents a guide for teachers to assist in the digital transformation of teaching and learning. They point to the need to guide and train teachers to understand the main issues related to distance learning, recognising the complementary relationship between formal and non-formal education. For quality online education, they identify a number of teacher competencies as essential: creating distance learning environments; emotional support and being a learning partner; micro-curriculum planning; instructional design planning; and tutoring. The impact of the COVID-19 pandemic on education and the adequate preparation of teachers is also reflected in the UNESCO [22] document *Transforming education from within*. It highlights the need to create conditions for the development of teacher competencies that will enable them to respond adequately to similar situations in the future, where the integration of digital technologies and innovative pedagogical practices will be essential.

6) e-Tools: This space will contain the applications and digital tools available to support students and teachers. The applications and tools that are acquired or developed, either as part of specific courses or for self-study, will also be made available in this area in the form of direct links.

7) e-Help: Since support and assistance to users is fundamental in any system, we had to consider including in *e-Campus* a space dedicated to this purpose. The students' support system should include the resources available to them to engage in the learning process (learning materials, library, teacher/facilitator) and the resources related to the mediation of the communication process (media and technology). Thus, by accessing the e-Help, users will have at their disposal a set of FAQs (Frequently Asked Questions), divided into categories covering different technical aspects. If the user does not find a solution to his doubt or difficulty, he can also fill in an incident form, selecting (from a drop-down list) the service he wishes to contact and which will receive the message.

8) Academic Portal: From the *e-Campus*, students can directly access the IPSantarém Academic Portal (through a direct link) and thus access the other services integrated in it.

The *e-Campus* will be accessed from the home page of the IPSantarém's website (see Fig. 2) [23] through a single sign-on (SSO). Once registered, the user will enter the *e-Campus* area directly. From there, students will be able to access all the above-mentioned areas.

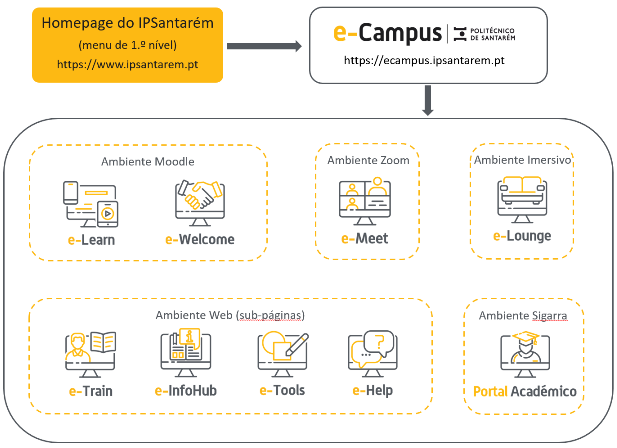


Fig. 2. IPSantarém's virtual campus access model

It will also be possible to access the virtual campus through smartphones by installing the IPSantarém *e-Campus* application on these devices. It is intended that the notification system of activities under development will contribute to the motivation and involvement of students in their learning, as well as helping them to manage their time effectively.

HEIs are reviewing their teaching practices, integrating more and more offline and online e-learning opportunities, and striving to incorporate students' digital skills acquired through the use of the Internet and smart devices. The widespread use of smartphones and mobile devices, the shift in methodology, methods and ways of learning from traditional to blended to digital, as well as the shift in learning from offline to online platforms is undeniable not only in individual learning but also in organisational frameworks. Students are increasingly using massive online learning platforms and self-directed learning through their own smart and mobile devices.

V. CONCLUSION AND FURTHER WORK

The *e-Campus* will enable the HEI to offer quality distance learning courses through an up-to-date, inclusive, student-centred technological support infrastructure. The CoViD-19 pandemic and emergency remote teaching have been a boost for HEIs, accelerating the development of pedagogical practices using active and innovative methodologies. Distance learning in Portugal, being now duly legislated, has room to grow and diversify the training offer, reaching different audiences, not only with regard to undergraduate courses, but also advanced training courses, micro-credit programmes and lifelong learning.

The development and consequent implementation of this virtual campus was only possible with the active participation of the institution and the funding of the *#eCapacitar project*. The funds from this project made it possible to hire companies, through national and international external tenders, that are currently developing all the spaces designed for the *e-Campus* of the IPSantarém, according to the development guidelines previously established by the project's team of experts in DL.

After the implementation of the *e-Campus*, there will be an analysis of the technology acceptance and the use and acceptance of e-learning. The *Technology Acceptance Method* (TAM) will be the basis for the understanding of the acceptance of the virtual campus among the users. The method will be justified by *Structural Equation Modelling* (SEM) using AMOS software.

ACKNOWLEDGMENT

#eCapacitar project is funded under the reference POCI-05-5762-FSE-000254.

REFERENCES

[1] Decreto-Lei n.º 133/2019 da Presidência do Conselho de Ministros, “Aprova o regime jurídico do ensino superior ministrado a distância” (2019). Série I de 2007-08-16, pp. 49-57. https://files.dre.pt/1s/2019/09/16800/0004900057.pdf

[2] Instituto Politécnico de Santarém, “Regulamento de Funcionamento, Frequência e Avaliação dos Cursos em Regime E-Learning da Escola Superior de Educação do Instituto Politécnico de Santarém”, Regulamento n.º 866/2015, de 21 de dezembro 2015. https://dre.pt/dre/detalhe/regulamento/866-2015-72939380

[3] J. Guerreiro, “ Ensino não presencial”, Despacho n.º 16/2022. Conselho de Administração da A3ES. https://www.a3es.pt/sites/default/files/Despacho16_2022_Ensino%20n%C3%A3o%20presencial.pdf

[4] Instituto Politécnico de Santarém, “Plano Estratégico 2019-2022. Instituto Politécnico de Santarém”, 2019. https://www.ipsantarem.pt/wp-content/uploads/2021/07/2-PLANO-ESTRAT%C3%89GICO-19-11-2019-1.pdf

[5] Agência de Avaliação e Acreditação do Ensino Superior, “Plano Estratégico 2021-2024”, 2022, Agência de Avaliação e Acreditação do Ensino Superior. https://a3es.pt/sites/default/files/A3ES_Plano_Estrategico.pdf

[6] A. Loureiro, I. Messias, D. Rocha, "Online Distance Learning - conceptualizing a tailored pedagogical model for a Higher Education Institution", ICEM23 Conference, unpublished.

[7] B. Khan, “The Global E-Learning Framework. E-learning”, 2010, pp. 42-51. Appendix_O_-_The_Global_e-Learning_Framewor-libre.pdf (d1wqtxts1xzle7.cloudfront.net)

[8] A. Pereira, A. Quintas-Mendes, L. Morgado, L. Amante, J. Bidarra, "Modelo Pedagógico Virtual da Universidade Aberta", Universidade Aberta, 2007. https://repositorioaberto.uab.pt/bitstream/10400.2/1295/1/Modelo%20Pedagogico%20Virtual.pdf

[9] R. Costa, A. Sargento, P. Gaspar, E. Machado, "Modelo de Ensino a Distância do Instituto Politécnico de Leiria", Instituto Politécnico de Leiria, 2010. https://www.researchgate.net/publication/356360429_Modelo_de_Ensino_a_Distancia_do_Instituto_Politecnico_de_Leiria

[10] e-Learning Pedagogical Support Unit, "Pedagogical Model for E-Learning", University of Nicosia, 2019. https://www.unic.ac.cy/wp-content/uploads/2020/09/UNIC-Distance-Learning-Pedagogical-Model.pdf

[11] A. Madeira et al., "Modelo Pedagógico em EaD da NOVA FCSH", FCSH, 2023. https://www.fcsh.unl.pt/static/documentos/media_e_eventos/Modelo%20Pedag%C3%B3gico%20de%20Ensino%20%C3%A0%20Dist%C3%A2ncia%20-%20NOVA%20FCSH.pdf

[12] Y. Chi and Q. An, "Design and Implementation of Virtual Campus System based on VR Technology," 2022 2nd Asia Conference on Information Engineering (ACIE), Haikou, China, 2022, pp. 44-47, doi: 10.1109/ACIE55485.2022.00015.

[13] Z. Min, "Research and Development of Virtual Digital Campus System Based on Android Platform," 2014 7th International Conference on Intelligent Computation Technology and Automation, Changsha, China, 2014, pp. 460-463, doi: 10.1109/ICICTA.2014.117.

[14] I. le Roux, K. Lazenby, D. Jordaan, "E-Learning and Virtual Campus Development: From Innovation to Sustainability." In Institutional Transformation through Best Practices in Virtual Campus Development: Advancing E-Learning Policies, edited by Mark Stansfield and Thomas Connolly, pp. 115-125. Hershey, PA: IGI Global, 2009. https://doi.org/10.4018/978-1-60566-358-6.ch008

[15] M. Maher, B. Skow, A. Cicognani, "Designing the virtual campus", Design Studies, Volume 20, Issue 4, July 1999, pp. 319-342. https://doi.org/10.1016/S0142-694X(98)00043-X

[16] A. De Lucia, R. Francese, I. Passero, G. Tortora, "Development and evaluation of a virtual campus on Second Life: The case of SecondDMI", Computer & Education, Volume 52, Issue 1, January 2009, pp. 220-233. https://doi.org/10.1016/j.compedu.2008.08.001

[17] S. D. Tripp, B. Bichelmeyer, “Rapid prototyping: An alternative instructional design strategy”, ETR&D 38, 31–44 (1990). https://doi.org/10.1007/BF02298246

[18] R. M. Branch, "Instructional Design: The ADDIE Approach", Springer ScienceþBusiness Media, 2009. https://link.springer.com/content/pdf/10.1007/978-0-387-09506-6.pdf

[19] Gagné, R. M., & Medsker, K. L. (1996). The conditions of learning: training applications. Fort Worth: Harcourt Brace.

[20] A. Loureiro, "Construção de conhecimento em ambientes virtuais : influência das relações interpessoais", 2013 [Doctoral Thesis] Universidade de Aveiro. http://hdl.handle.net/10773/11532

[21] F. Miao, R. Huang, D. Liu, R. Zhuang, "Ensuring effective distance learning during COVID-19 disruption: guidance for teachers", UNESCO, 2021. https://unesdoc.unesco.org/ark:/48223/pf0000375116_por

[22] UNESCO, "Transforming education from within: current trends in the status and development of teachers", 2022. https://unesdoc.unesco.org/ark:/48223/pf0000383002

[23] A. Loureiro, D. Rocha, I. Messias, “Do ensino presencial ao ensino a distância: desenho e conceção do e-Campus do IPSantarém”, Poster presented at CNaPPES23, pp. 250-252, Faro 6-7 july 2023, Portugal. http://cnappes.org/files/2023/07/Livro-de-Resumos-Cnappes-v8.pdf

A EMERGÊNCIA DA ALGORITMIA NO 1.º ANO DE ESCOLARIDADE: UM ESTUDO NO ÂMBITO DAS APRENDIZAGENS ESSENCIAIS DE MATEMÁTICA

The emergence of algorithmics in grade 1: a study framed in the new Portuguese Mathematics curriculum

Célia Mestre
Instituto Politécnico de Setúbal
Escola Superior de Educação
Portugal
celia.mestre@ese.ips.pt

Cristina Martins
Centro de Investigação em Educação Básica
Instituto Politécnico de Bragança, Portugal
mcesm@ipb.pt

Cândida Tourais
Agrupamento de Escolas de Azeitão
Portugal
candida.tourais@sapo.pt

Isabel Guerra
Agrupamento de Escolas Miguel Torga
Bragança
Portugal
zabelguerra@gmail.com

***Resumo* — Este artigo apresenta um estudo realizado com duas turmas do 1.º ano de escolaridade, no contexto da operacionalização das novas Aprendizagens Essenciais de Matemática do Ensino Básico. Conduziu-se uma sequência de tarefas com o objetivo de promover o desenvolvimento do pensamento computacional, articulado com aprendizagens do tema Números, e procurou-se identificar as cinco práticas do pensamento computacional na atividade dos alunos. Concluiu-se que os alunos mobilizaram todas as práticas, destacando-se a emergência da algoritmia e, em simultâneo, essas práticas permitiram aprofundar os seus conhecimentos matemáticos no conteúdo explorado no tema Números.**

Keywords— Pensamento Computacional, algoritmia, Aprendizagens Essenciais de Matemática, Números

***Abstract*— This article presents a study carried out with two grade 1 classes, in the context of implementing the new Mathematics' curriculum. A sequence of tasks was carried out with the propose of develop computational thinking, articulated with learning about the theme Numbers, and an attempt was made to identify the five practices of computational thinking in the students' activities. It is concluded that the students mobilized all the practices, highlighting the emergence of algorithmics and, at the same time, these practices allowed them to deepen their mathematical knowledge in the content explored in the theme Numbers.**

Keywords— Computational Thinking, algorithmics, new Mathematics' curriculum, Numbers

I. INTRODUÇÃO

O pensamento computacional é apresentado como uma capacidade transversal no currículo de Matemática do Ensino Básico, pela primeira vez, em Portugal. O novo currículo, no formato de Aprendizagens Essenciais de Matemática para o Ensino Básico (Canavarro et al., 2021), de agora em diante designadas apenas por Aprendizagens Essenciais, integra como conteúdos de aprendizagem tanto os conhecimentos matemáticos como seis capacidades matemáticas transversais, entre as quais o pensamento ccomputacional.

Entendido como um processo de resolução de problemas, o pensamento computacional apresenta-se definido, no novo currículo, através de um conjunto de cinco práticas angulares: abstração, decomposição, reconhecimento de padrões, algoritmia e depuração. Neste artigo centrar-nos-emos na mobilização dessas práticas no desenvolvimento de uma sequência de tarefas implementada em duas turmas do 1.º ano de escolaridade, no âmbito da operacionalização das novas Aprendizagens Essenciais. Através das atividades que os alunos realizaram enquanto exploravam as tarefas da sequência, procuraremos identificar as práticas do pensamento computacional e apresentar evidências da sua mobilização, refletindo sobre a forma como os alunos desenvolveram o seu pensamento computacional, em articulação com as aprendizagens matemáticas enquadradas no tema Números.

II. ENQUADRAMENTO TEORICO

Para Wing (2006), a capacidade do pensamento computacional é fundamental e deve ser desenvolvida por qualquer aluno, em paralelo com outras capacidades essenciais, tais como o domínio da leitura, da escrita ou da aritmética. O pensamento computacional vai muito além da capacidade de programar "por se centrar na conceptualização" e requerer "pensamento em múltiplos níveis de abstração" (Wing, 2006, p. 35), sendo uma forma de pensamento que os humanos usam, não os computadores. Pode ser considerado como um processo de pensamento que envolve a formulação de problemas e o modo de procura das soluções, soluções essas que podem ser representadas de uma forma que possa ser efetivamente realizada por um agente de processamento de informações, como um computador, mas não necessariamente (Wing, 2010). Desta forma, assume-se que não é condição essencial para o desenvolvimento do pensamento computacional o recurso à tecnologia ou sequer à programação, embora se reconheça a sua pertinência e finalidade. De igual forma, também se considera que a utilização da tecnologia não implica necessariamente que esteja a ser promovido o desenvolvimento do pensamento computacional.

O novo documento curricular apresenta como um dos oito objetivos gerais de aprendizagem o desenvolvimento da capacidade do pensamento computacional, assumindo-se que este "pressupõe o desenvolvimento, de forma integrada, de práticas como a abstração, a decomposição, o reconhecimento de padrões, a análise e definição de algoritmos, e o desenvolvimento de hábitos de depuração e otimização dos processos" (Canavarro et al., 2021, p. 3), práticas já referidas como características deste tipo de pensamento por autores como Angeli et al. (2016) ou Yadav et al. (2019). O documento refere ainda que estas práticas "são imprescindíveis na atividade matemática e dotam os alunos de ferramentas que lhes permitem resolver problemas, em especial relacionados com a programação" (idem).

Sendo também um dos autores do novo documento curricular, Espadeiro (2021) enquadra e sistematiza o entendimento que é dado a cada uma dessas práticas.

- A abstração pretende reduzir a complexidade de uma tarefa ou problema, ou identificar princípios gerais que podem ser aplicados em situações ou problemas similares;
- A decomposição trata da gestão de tarefas ou situações complexas dividindo-as em partes menores e mais fáceis de gerir;
- O reconhecimento de padrões envolve reconhecer regularidades e relações;
- A algoritmia permite desenvolver uma solução passo a passo para um dado problema (etapas de resolução) ou estabelecer regras (condições) a serem seguidas para resolver o problema; e,
- A depuração corresponde a procurar e corrigir erros, assumindo, de igual modo, ações de testagem, verificação, refinamento e otimização da resolução apresentada (p. 6).

Para que os alunos desenvolvam o pensamento computacional, é essencial que mobilizem e interrelacionem estas práticas (Angeli et al., 2016) na exploração de uma tarefa matemática. No entanto, a sua natural inter-relação e dependência não facilita o reconhecimento de cada uma isoladamente, nem se considera que isto seja necessário na perspetiva do aluno. Por outro lado, será importante para o professor reconhecer cada uma destas práticas no trabalho dos alunos de modo a poder promover intencionalmente o desenvolvimento de todas, de forma integrada. Assim, reconhecemos, neste artigo, a importância de se procurar identificar a presença de cada uma dessas práticas na atividade que os alunos desenvolvem quando exploram uma tarefa matemática, de forma a poder compreender o desenvolvimento desta capacidade matemática no seu todo, em consonância com os objetivos definidos nas Aprendizagens Essenciais. Consideramos ainda que, embora todas estas práticas possam estar presentes na exploração de uma tarefa, essa não é uma condição essencial para que se promova o desenvolvimento do pensamento computacional. Por exemplo, uma das práticas que poderá considerar-se menos acessível aos alunos dos primeiros anos de escolaridade é a prática da algoritmia e, de facto, esta não é imprescindível para que os alunos desenvolvam o pensamento computacional.

Ainda assim, são vários os estudos que mostram a pertinência de se introduzir, nos primeiros anos de escolaridade, o pensamento algorítmico (e.g. Mittermeir, 2013; Voronina et al., 2016; Figueiredo et al., 2021). Por exemplo, Voronina et al. (2016), num estudo com alunos de 6 e 7 anos de idade, introduziram a prática da algoritmia através de atividades ligados ao jogo. No decorrer deste estudo elaboraram um quadro conceptual que permite compreender o desenvolvimento do pensamento algorítmico através de três estádios que representam uma progressão no desenvolvimento da algoritmia em alunos dessas idades. Assim, enquanto no primeiro estádio os alunos aprendem a aplicar algoritmos dados, no segundo são confrontados com maior diversidade de algoritmos e já realizam atividades de completamento desses algoritmos, ao invés de apenas os aplicarem. No terceiro e último estádio, de acordo com os autores, os alunos são já capazes de transferir algoritmos aprendidos para outras atividades semelhantes, modificando-os para conseguir resultados diferentes, sendo até capazes de produzir novos algoritmos.

Tal como já foi referido, o recurso à tecnologia não é condição imprescindível para o desenvolvimento do pensamento computacional. Isso também se aplica à prática da algoritmia, podendo a mesma ser trabalhada com recurso a papel e lápis e/ou materiais manipuláveis não digitais. No entanto, é inegável o papel da tecnologia quando usada de forma apropriada ao serviço da promoção das aprendizagens. Um exemplo de um recurso tecnológico com potencialidades já reconhecidas é a linguagem de programação visual Scratch. Considerando que o desenvolvimento da algoritmia exige a utilização de algum tipo de linguagem, seja textual ou gráfica (Mittermeir, 2013), a utilização do Scratch pode permitir o desenvolvimento desta prática, sendo de utilização fácil e muito apelativa até para aqueles que nunca experienciaram a programação (Resnick et al., 2009). Através deste recurso, os alunos podem desenvolver o pensamento algorítmico numa progressão que pode contemplar os três estádios apresentados por Voronina et al. (2016). Assim, podem começar por experimentar projetos já existentes numa perspetiva apenas de utilizador, posteriormente podem reutilizá-los e fazer pequenas modificações nas programações desses projetos até, desejavelmente, poderem criar os seus próprios projetos. Desta forma, esta ferramenta tecnológica parece-nos ter potencialidades importantes para o desenvolvimento do pensamento algorítmico, sendo inclusivamente proposta nas orientações didáticas para o professor no novo documento curricular, pois possibilita o desenvolvimento do pensamento computacional, de forma incremental e interativa, com sucessivas tentativas e correções de erros (Brennam & Resnick, 2012).

III. METODOLOGIA

Nesta secção descrevem-se brevemente as opções metodológicas, os participantes, a sequência de tarefas que foi objeto deste estudo e apresentam-se as categorias de análise usadas.

P. Opções metodológicas

Este estudo enquadra-se numa metodologia de natureza qualitativa, tendo como principal propósito descrever e interpretar as práticas de pensamento computacional que emergiram do trabalho dos alunos na exploração de uma sequência de tarefas desenvolvida nas duas turmas do 1.º ano de escolaridade que se encontravam a operacionalizar o novo currículo de Matemática. Os dados foram recolhidos durante o trabalho em sala de aula através de notas de campo, do registo fotográfico das produções dos alunos e gravação áudio dos momentos de trabalho autónomo e de discussão coletiva.

Q. Participantes

Os participantes neste estudo foram os alunos das duas turmas de 1.º ano que estavam a trabalhar o novo currículo no ano letivo 2021/22, antes da fase de implementação a nível nacional. Nesse âmbito, as quatro autoras deste artigo formaram uma equipa de trabalho colaborativo onde as primeiras duas tinham como função apoiar as professoras titulares de turma (restantes duas autoras do artigo) na implementação do novo documento curricular. O trabalho colaborativo desenvolveu-se no âmbito de reuniões semanais para planificação de tarefas e análise da sua implementação nas salas de aula, refletindo-se sobre os diferentes aspetos de concretização e condução da aula, com centralidade na tarefa desenvolvida e no trabalho das professoras e dos alunos e das aprendizagens e dificuldades que ambos sentiram. As duas primeiras autoras deste artigo faziam ainda um acompanhamento mais regular às turmas, assistindo e participando em algumas aulas.

As duas turmas do 1.º ano pertenciam a escolas públicas de diferentes regiões do país, uma do concelho de Bragança e outra do concelho de Setúbal. Respetivamente, as turmas tinham 22 e 24 alunos, todos a frequentar o 1.º ano de escolaridade pela primeira vez. Os dados foram recolhidos no 3.º período do aluno letivo e a média de idades dos alunos era 7 anos.

R. A sequência de tarefas matemáticas

A sequência de tarefas que apresentamos neste artigo é formada por três tarefas interrelacionadas, que denominamos da seguinte forma: 1) Quantos números consegue escrever o robô Numi?; 2) Completar e corrigir instruções; 3) Entrar na cabeça do Numi. Na primeira tarefa surge a figura de um robô no enunciado da tarefa. Este robô foi apresentado aos alunos como alguém que obedecia às ordens que lhe eram dadas, as quais tinham de ser muito claras e precisas. A partir desta primeira tarefa foram construídas as seguintes.

S. Análise dos dados

Para identificar as práticas de Pensamento Computacional que emergiram da atividade dos alunos enquanto exploravam as tarefas matemáticas, criaram-se as categorias de análise que se apresentam no Quadro 1.

QUADRO 1 – CATEGORIAS DE ANÁLISE DAS PRÁTICAS DE PENSAMENTO COMPUTACIONAL NA ATIVIDADE DOS ALUNOS

Práticas do PC	**Indicadores na exploração das tarefas**
Abstração	- Identifica a informação essencial - Mobiliza a informação essencial
Decomposição	- Divide em partes menores - Mobiliza essa divisão para resoluções parciais
Reconhecimento de padrões	- Reconhece regularidades - Mobiliza as regularidades na resolução
Algoritmia	- Reconhece as etapas necessárias - Reconhece a ordem das etapas necessárias - Mobiliza a sequência de passos
Depuração	- Identifica erros - Corrige erros - Otimiza soluções corretas

As tarefas foram construídas no seio do grupo de trabalho colaborativo e implementadas nas duas turmas. Para a exploração de cada tarefa, em sala de aula, seguiu-se um modelo de natureza exploratória, caracterizada pelas três fases seguintes: 1) apresentação da tarefa; 2) trabalho autónomo dos alunos em pares; e 3) Discussão coletiva com toda a turma e sistematização das aprendizagens. Neste artigo apresentam-se evidências do trabalho dos alunos nas três tarefas, não se identificando nenhuma das duas turmas, por se considerar que os desempenhos dos alunos não foram significativamente diferentes.

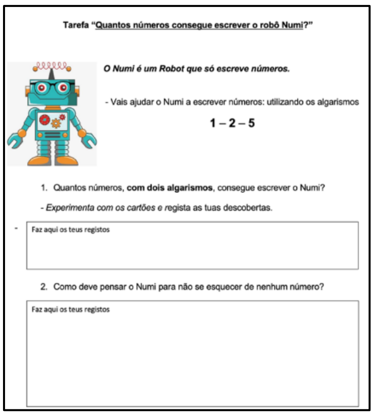
IV. APRESENTAÇÃO DOS RESULTADOS

Apresenta-se, em seguida, a descrição e análise da atividade dos alunos em cada uma das três tarefas da sequência já referidas. Nessa análise são apresentadas evidências das cinco práticas de pensamento computacional.

T. Tarefa "Quantos números consegue escrever o robô Numi?"

Nesta tarefa (Figura 1) apresentavam-se três algarismos e era solicitado que os alunos escrevessem todos os números possíveis de dois algarismos, dados esses três. Para além do enunciado da tarefa era entregue a cada par de alunos um conjunto de cartões com os algarismos escritos, com a intenção de os poderem facilmente mover e descobrir os números possíveis.

Nas duas turmas, os alunos conseguiram, muito facilmente, descobrir e registar os seis números possíveis. Para tal, foi percetível que os alunos se centraram nos algarismos dados e na construção de números com dois algarismos, identificando e mobilizando a informação essencial, revelando, assim, a utilização da prática da abstração. Esta prática foi, assim, facilmente e de forma natural, mobilizada pelos alunos das duas turmas.


Tarefa "Quantos números consegue escrever o robô Numi?"

O Numi é um Robot que só escreve números.

- Vais ajudar o Numi a escrever números: utilizando os algarismos

1 – 2 – 5

1. Quantos números, **com dois algarismos**, consegue escrever o Numi?

- *Experimenta com os cartões e regista as tuas descobertas.*

Faz aqui os teus registos

2. Como deve pensar o Numi para não se esquecer de nenhum número?

Faz aqui os teus registos

Fig. 1. Enunciado da tarefa "Quantos números consegue escrever o robô Numi?".

A segunda questão desta tarefa revelou-se mais exigente e era aquela que, intencionalmente, promovia a utilização de algum pensamento algorítmico, pois solicitava aos alunos que mostrassem "Como deve pensar o robô Numi para não se esquecer de nenhum número?". Para responder a esta questão, os alunos tinham de mobilizar o procedimento realizado anteriormente quando descobriram todos os números possíveis. Por outro lado, tinham de traduzir esse procedimento de forma muito clara e precisa para o poderem "transmitir" ao robô Numi, sendo desejável que definissem uma estratégia para que nenhum número possível fosse esquecido. Na primeira abordagem a esta segunda questão, os alunos não mobilizaram o conhecimento e os procedimentos que tinham, facilmente, usado na primeira questão. Foi-lhes difícil perceber da importância da completude e precisão das instruções a dar ao robô Numi. Naturalmente que esta questão exigia "voltar atrás" e pensar como tinham procedido, o que, naturalmente, não é imediato para os alunos deste nível de escolaridade. Nesta altura, o papel das professoras foi muito importante, conduzindo os alunos a focarem a sua atenção na necessidade de identificar as diferentes etapas e na importância da sua precisão. O excerto seguinte é um exemplo de um momento de aula, durante a fase do trabalho autónomo dos alunos, onde a professora procura que os alunos compreendam a necessidade das instruções serem claras e completas.

Professora - Vocês têm de dar ordens ao Numi. Numi primeiro faz assim... com estes algarismos, primeiro o Numi pode fazer o quê?

Aluno – Tem de pegar nos números.
Professora – Mas pega em todos?
Aluno – Não.
Professora – Então pega em quê? Diz ao Numi... Numi primeiro pega no cartão que tem o número...
Aluno – Um. E depois pegas no cartão que tem o número 2.
Professora – E ele faz o quê?
Aluno – E faz o número 12.
Professora – Mas ele pode pegar como ela fez [colocou o cartão do 2 por baixo do cartão do 1]. Então o que é que ele tem de fazer a esse cartão do 2?
Aluno – Por ao lado do 1.
Professora – De que lado?
Aluno – Do lado direito.

Neste último momento deste episódio de aula, a tradução clara através do movimento dos cartões das instruções dadas pelo aluno, conduzi-o a reconhecer não só as etapas necessárias como a necessidade de ser preciso nas instruções que dava. De facto, neste excerto, a ação da professora em colocar um cartão por baixo do outro, conduziu o aluno à necessidade de indicar exatamente a posição em que teria de ser colocado cada cartão. De forma muito intuitiva, ambas as professoras sentiram necessidade de *incorporar* o Numi, fazendo de robô e seguindo restritivamente as ordens que os alunos lhes iam dando, conduzindo-os a verificarem se as mesmas eram ou não eficazes. Estas ações das professoras contemplavam os dois aspetos identificados como indicadores para a prática da algoritmia: o reconhecimento das etapas necessárias e da ordem dessas etapas. Por outro lado, o facto de reproduzirem exatamente as instruções dadas pelos alunos, mostrando-lhes o resultado dessas mesmas instruções, permitia também que os alunos reconhecessem de imediato a sua ineficácia e incompletude. Este momento é, assim, exemplificativo da mobilização da prática de depuração, levando os alunos a identificarem e corrigirem os erros. Refira-se ainda que a manipulação dos cartões foi facilitadora nesse processo, pois tornou tangível a reprodução fiel das instruções que os alunos davam, conduzindo-os a identificarem as falhas e os erros e a corrigirem-nos.

Consideramos que as dificuldades apresentadas pelos alunos se centram na prática da algoritmia, mais concretamente no reconhecimento das etapas necessárias e na sua ordem e não se prendem com conhecimentos relacionados com a lateralidade ou outros conceitos de orientação espacial. Os alunos conseguiam reconhecer ou diferenciar a esquerda e a direita, o em cima e em baixo, mas não mobilizaram, imediatamente e de forma natural, esses conceitos para a construção das instruções para a escrita dos números. Assumiam que essas instruções não eram necessárias por as terem traduzido em ação de forma muito natural quando manipulavam os cartões. Ou seja, a dificuldade prendia-se na construção completa e exata do algoritmo.

Ao serem conduzidos à necessidade de usarem os conceitos de lateralização para a construção das instruções, facilmente os alunos perceberam que apenas precisariam dar as instruções de alterar as posições dos cartões para obter novos números com os mesmos algarismos, como mostra o excerto seguinte:

Aluno - Está aqui o 12, agora trocamos os números, o 2 vem para aqui e o 1 vem para aqui e fazemos o 21.
Professora – E quantos números consegues construir com essa estratégia?
Aluno – Dois.
Professora – E depois consegues construir outros ou não?
Aluna – Sim, depois o 25, o 52.

Este excerto mostra como os alunos começaram a usar uma estratégia de resolução do problema, obtendo números diferentes pela troca da ordem dos cartões, usando, assim, as regularidades do sistema de numeração decimal, mais concretamente no que respeita à posição do algarismo no número. Desta forma, no que concerne às práticas do pensamento computacional, denota-se aqui a prática do reconhecimento de padrões, tendo os alunos reconhecido e mobilizado as regularidades do sistema de numeração decimal. Para mostrarem os seus processos de raciocínio, os alunos recorreram a movimentos que faziam com os dedos, manipularam diretamente os cartões ou usaram esquemas de setas na escrita dos números, usando, assim, diferentes representações (Figura 2).

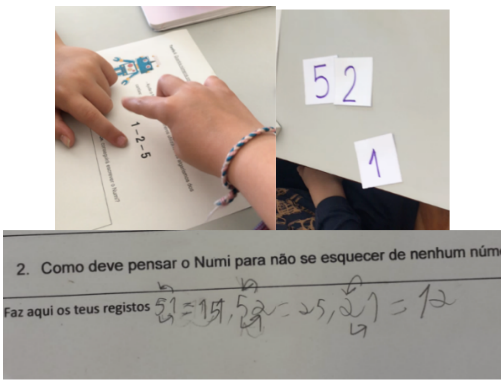


Fig. 2. Estratégia de troca de posição dos algarismos nos números.

Os alunos usaram ainda outras estratégias, tais como a escrita por ordem crescente ou decrescente dos números possíveis ou ainda a escrita de todos os números que "começavam" com o mesmo algarismo, ou seja, esgotando todos os números possíveis com o algarismo em determinada posição (Figura 3). Estas regularidades permitiram dividir o problema em partes menores, mobilizando essa divisão em resoluções parciais, ou seja, por exemplo, ao começar por escrever todos os números que tinham um determinado algarismo na posição das dezenas, subdividiu-se o problema em partes menores, usando-se a prática da decomposição. Da mesma forma, se procedeu quando se recorreu à ordenação dos números.

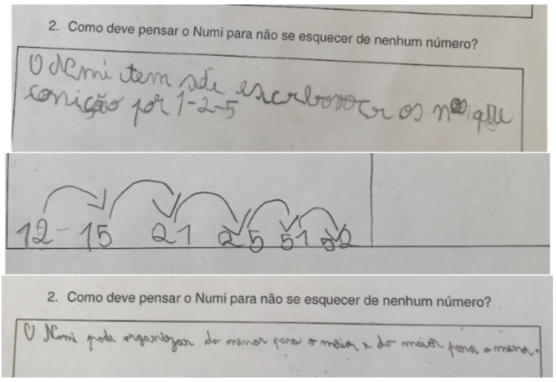


Fig. 3. Resoluções dos alunos que mostram outras estratégias usadas.

U. Tarefa "Completar e corrigir instruções"

Nesta tarefa da sequência pretendia-se que os alunos continuassem a desenvolver o seu pensamento algoritmico, de forma intencional. Assim, era proposto que completassem e corrigissem instruções dadas.

Inicialmente distribuiram-se aos alunos cartões com instruções incompletas para que as completassem. Os alunos começaram a usar os cartões, mas, de forma muito natural, começaram a criar outras instruções igualmente válidas, diferentes daquelas já formuladas nos cartões dados. Assim, aparentemente, os cartões forneceram aos alunos um modelo mas, rapidamente e de forma muito autónoma, foram deixados de lado, e os alunos foram capazes de formular outras instruções revelando já uma compreensão do pretendido e demonstrando também alguma criatividade nessa formulação. Posteriormente, noutra parte da tarefa era pedido aos alunos para corrigirem instruções erradas ou incompletas, não os restringindo a uma formulação prévia e permitindo-lhes maior liberdade na reelaboração das instruções (Figura 4).

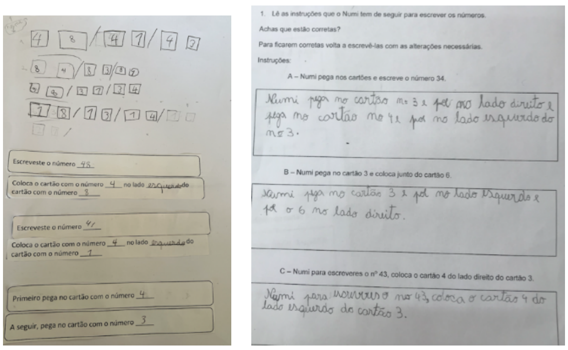


Fig. 4. Resoluções dos alunos na tarefa "Corrigir e completar instruções".

Relativamente às práticas do pensamento computacional, apresenta-se o que se considera serem evidências da mobilização dessas práticas. Quando os alunos precisaram identificar se a informação que estava nas instruções era suficiente ou estava correta, concentrando a sua atenção no essencial, mobilizaram a prática da abstração. Usaram a decomposição quando diferenciaram as instruções corretas das incorretas e identificaram os elementos em falta, analisando por partes as instruções que lhes eram apresentadas. Usaram o reconhecimento de padrões já identificados na tarefa anterior e mobilizaram-nos para completar ou corrigir as instruções dadas. Nitidamente trabalharam a prática da algoritmia, reconhecendo quais as etapas que eram apresentadas, quais as que faltavam ou estavam incorretas e validando a sua ordem. A depuração foi usada na identificação e correção dos erros nas instruções incorretas e ao detetarem a sua incompletude.

V. Tarefa "Entrar na cabeça do Numi"

A terceira e última tarefa desta sequência pretendia fazer uma iniciação à linguagem de programação visual Scratch. Neste sentido, foi criada uma programação com um jogo numérico em que era pedido aos alunos que indicassem um número e, em seguida, era apresentado outro número pelo Numi (no Scratch). Os alunos tinham de descobrir quais as instruções que tinham sido dadas ao Numi para que ele produzisse o novo número. Na realização do jogo, nas duas turmas, os alunos conseguiram de forma muito imediata, descobrir as instruções que tinham sido dadas ao Numi e que consistiam em comandos como adicionar ou subtrair 1 ou 10 aos números que estes indicavam (Figura 5).

Fig. 5. Atividade dos alunos na tarefa "Entrar na cabeça do Numi".

Após esse momento, as professoras referiram que iam *entrar dentro da cabeça do Numi*, ou seja, perceber como o Numi tinha pensado. Naturalmente que, nesta fase, foi apresentada e explicada de forma simples a programação feita em Scratch (Figura 6).

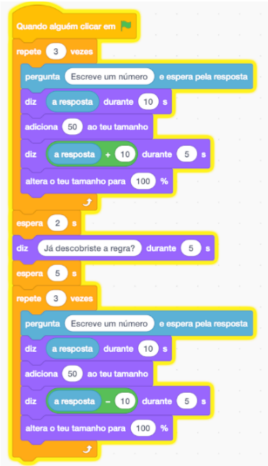


Fig. 6. Programação em Scratch apresentada aos alunos e que estes modificaram.

Após esse momento, os alunos, nos seus tablets, tiveram acesso às programações em Scratch e foram desafiados a criarem eles próprios novas instruções, obtendo novos jogos numéricos que jogariam a pares. Todos os pares conseguiram modificar as instruções dadas, usando novos comandos como adicionar ou subtrair outros números para além do 1 e do 10.

Nesta tarefa, os alunos mobilizaram as práticas do pensamento computacional em diferentes momentos. Por exemplo, ao centrar a atenção no número que obtinham no Scratch, mobilizavam a prática de abstração. Quando identificavam, no algoritmo dado, as partes que tinham de alterar para produzir novas instruções, fizeram-no decompondo o algoritmo dado. Usaram os padrões ao reconhecerem as regras apresentadas na programação em Scratch e usaram a depuração quando reconheceram erros tanto nas regras que identificavam, como nas que criavam. E, naturalmente, trabalharam de forma clara a prática da algoritmia ao confrontarem-se com o algoritmo dado para descobrirem a regra e ao alterarem-no para produzir novas regras.

V. DISCUSSÃO DOS RESULTADOS

Considerando os indicadores relativos às práticas do pensamento computacional apresentados e às evidências refletidas na atividade dos alunos na exploração das tarefas, apresentamos o Quadro 2 que sitematiza essas evidências, ao longo das três tarefas analisadas. As cinco práticas estiveram presentes em todas as tarefas da sequência descritas e mobilizaram aspetos relativos à compreensão do tema Números. Por exemplo, o reconhecimento de padrões tornou evidentes as regularidades do sistema de numeração decimal, quer através do reconhecimento da posição de um algarismo no número e do valor que este assumia, como o reconhecimento da ordenação dos números. A abstração permitu também lidar com aqueles algarismos e números em específico ou centrar a atenção nas instruções a completar ou corrigir e ainda nos números pedidos e obtidos a partir da programação em Scratch. A decomposição permitiu diferentes abordagens ao mesmo problema, enriquecendo também outros aspetos relativos ao conteúdo matemático como a ordenação dos números, por exemplo. A prática da depuração, extremamente importante na atividade matemática, foi possível evidenciar-se nas três tarefas descritas, quando os alunos corrigiam ou melhoravam as instruções.

No trabalho dos alunos foram evidentes os três estádios identificados por Voronina et al. (2016) no que concerne à prática da algoritmia, sendo progressivas as situações de completamento e de alteração de algoritmos. Relativamente à utilizaçao do ambiente de programação visual Scratch, saliente-se que, para além dos fatores relativos à motivação e interesse dos alunos, foi possível trabalhar com os operadores matemáticos do próprio ambiente para descoberta ou alteração das regras dadas, as quais exploravam regularidades aritméticas. No entanto, importa referir igualmente que a prática de algoritmia não foi evidente apenas na tarefa onde se usou o Scratch, pois esta foi sendo trabalhada nas tarefas anteriores que não utlizavam qualquer ferramenta tecnológica. Embora não consideremos imprescindível trabalhar a prática da algoritmia em todas as tarefas que promovam o pensamento computacional, tal como refere Wing (2010), esta prática parece ser o pilar agregador de todas as outras e, neste estudo, mostramos como ela sumariza e permite tornar evidente a mobilização das restantes práticas. Assim, parece-nos possível desenvolver tarefas onde as restantes práticas sejam mobilizadas sem que se conduza intencionalmente à prática da algoritmia, mas o contrário não será tão evidente, ou seja, o desenvolvimento da algoritmia parece exigir a presença de todas as outras.

QUADRO 2 – EVIDÊNCIAS DAS PRÁTICAS DO PENSAMENTO COMPUTACIONAL QUE EMERGIRAM DO TRABALHO DOS ALUNOS NAS TRÊS TAREFAS DA SEQUÊNCIA

Tarefas / Práticas do PC	Evidências do trabalho dos alunos		
	"Quantos números consegue escrever o robô Numi?"	**"Completar e corrigir instruções"**	**"Entrar na cabeça do Numi"**
Abstração	- Centrar a atenção nos 3 algarismos que eram propostos e na formação de números com 2 algarismos	- Centrar a atenção apenas na instrução a completar ou corrigir	- Centrar a atenção no número que colocaram e no número dado pelo Numi, tanto quando o algoritmo é dado como quando lhes é possibilitado alterar o algoritmo
Decomposição	Surgiram 3 abordagens diferentes: - Começar por formar os números usando apenas 2 dos 3 algarismos e, em seguida, trocar a posição desses algarismos para produzir novos números; - Descobrir todos os números possíveis para cada um dos algarismos, tratando cada um individualmente - Descobrir os números ordenando-os de forma crescente ou decrescente.	- Diferenciar os elementos corretos da instrução dos incorretos - Identificar os elementos em falta	- Decompor o algoritmo dado, identificando qual ou quais as partes a alterar
Reconhecimento de padrões	- A troca da posição dos algarismos no número permite descobrir dois números diferentes e isso acontece sempre (conceito de valor posicional); - Para formar números com dois algarismos dados três algarismos, com cada algarismo conseguimos escrever 4 números diferentes e, excluindo as repetições, obtemos 6 números diferentes.	- Para corrigir ou completar as instruções é sempre necessário usar o valor posicional dos algarismos	- Descobrir que a mesma regra é dada para 4 números diferentes - Descobrir regularidades nos algoritmos dados e que têm de alterar (onde alteram e como e o que resulta dessa alteração)
Algoritmia	- Definir por passos sequenciais e completos o processo de criar os 6 números possíveis	- Corrigir ou completar a sequência de passos apresentada na instrução, obedecendo à ordem correta e incluindo todos os elementos necessários	- Compreender o algoritmo apresentado ("o que está na cabeça do Numi") - Alterar o algoritmo dado de forma a apresentar regras diferentes
Depuração	- Corrigir tentativas que não obedecem às condições dadas (formar números com dois algarismos dados três algarismos) - Excluir os números repetidos - Corrigir as instruções erradas - Tornar as instruções mais claras e específicas	- Detetar o erro e corrigi-lo - Detetar a incompletude e completar	- Identificar eventuais erros quando alteram o algoritmo dado e corrigi-los

Importa ainda referir que, no caso do presente estudo, este trabalho com os números parece propício à emergência da algoritmia por permitir que as regularidades do sistema de numeração decimal possam ser traduzidas dessa forma. Outros tópicos ou subtópicos matemáticos poderão não apresentar essa facilidade, especialmente nos primeiros anos de escolaridade.

Concluímos ainda referindo a pertinência da exploração integrada do pensamento computacional com os outros temas matemáticos e reforçamos a importância de trabalhar intencionalmente cada uma das suas práticas e de procurar evidências no trabalho dos alunos que permitam perceber como estes as mobilizam e desenvolvem.

REFERENCIAS

[1] Angeli, C., Voogt, J., Fluck, A., Webb, M., Cox, M., Malyn-Smith, J., & Zagami, J. (2016). A K-6 Computational Thinking Curriculum Framework: Implications for Teacher Knowledge. Educational Technology & Society, 19 (3), 47–57.

[2] Brennan K, Resnick M (2012). New frameworks for studying and as-sessing the development of computational thinking. Presented at the American Education Researcher Association, Vancouver, Ca-nada.

[3] Canavarro, A.P., Mestre, C., Gomes, D., Santos, E., Santos, L., Brunhei-ra, L., Vicente, M., Gouveia, M. J., Correia, P., Marques, P., & Espadeiro, G. (2021). Aprendizagens Essenciais de Matemática no Ensino Básico. ME-DGE. https://www.dge.mec.pt/sites/default/files/Curriculo/Aprendizagens_Essenciais/1_ciclo/ae_mat_1.o_ano.pdf

[4] Espadeiro, R. G. (2021). O pensamento computacional no currículo de Matemática. Educação e Matemática, 162, 5-10.

[5] Figueiredo, M., Amante, S., Gomes, H., Gomes, C.A., Rego, B., Alves, V. & Duarte, R. P. (2021). Algorithmic thinking in early child-hood education: opportunities and supports in the portuguese con-text. In Proceedings of EDULEARN21 Conference.

[6] Mittermeir, R. T. (2013). Algorithmics for preschoolers—A contradiction? Creative Education, 4(09), 557.

[7] Voronina, L.V., Sergeeva, N. N., Utymova, E. A. (2016). Development of algorithm skills in preschool children. Procedia – Social and Be-havioral Sciences 233, 155-159.

[8] Wing, J. (2006). Computational thinking. Communications of the Asso-ciation for Computing Machinery, pp. 152-155.

[9] Wing, J. (2010). Computational Thinking: What and Why? https://www.cs.cmu.edu/~CompThink/resources/TheLinkWing.pdf

[10] Yadav, A., Larimore, R., Rich, K., Schwarz, C. (2019). Integrating com-putational thinking in elementary classrooms: Introducing a toolkit to support teachers. In Proceedings of Society for Information Technology & Teacher Education International Conference 2019.K. Elissa, “Title of paper if known,” unpublished.

REFLEXÕES SOBRE UMA UC DE TECNOLOGIAS NA FORMAÇÃO INICIAL DE PROFESSORES: A PERSPETIVA DOS ESTUDANTES.

Maria do Rosário Rodrigues
Escola Superior de Educação
Instituto Politécnico de Setúbal
Setúbal, Portugal
ORCID: 0000-0002-9935-6917

João Vítor Torres
Escola Superior de Educação
Instituto Politécnico de Setúbal
Setúbal, Portugal
ORDID: 0000-0002-9995-4511

João Carlos Grácio
Escola Superior de Educação
Instituto Politécnico de Setúbal
Setúbal, Portugal
ORCID: 0000-0002-6648-8446

Abstract—**No presente texto apresentamos uma reflexão em torno do desenvolvimento de uma Unidade Curricular, semestral, do curso de Licenciatura em Educação Básica de uma Escola Superior de Educação, tentando perceber se os objetivos estabelecidos para a UC foram atingidos, na perspetiva dos estudantes que a frequentaram, utilizando metodologias ativas de aprendizagem, e portfólios digitais. Utilizamos uma metodologia qualitativa, tendo como principal objeto de recolha de dados os textos produzidos pelos alunos, na última das 10 tarefas propostas, onde refletiram sobre o funcionamento da UC. Os resultados apontam para uma aceitação, por parte dos estudantes, das metodologias e instrumentos usados, valorizando os conteúdos abordados e a importância da mesma no seu percurso académico.**

PALAVRAS-CHAVE— Formação Inicial, Tecnologias Digitais, Portfólios Digitais, Aprendizagem Ativa

I. INTRODUÇÃO

No primeiro semestre de 2022/23, os autores deste texto lecionaram a unidade curricular (UC) Expressões e Tecnologias. Foi a primeira vez que lecionaram em conjunto esta UC e, por isso, consideraram relevante refletir sobre o seu funcionamento. A UC tem um caráter eminentemente prático, pelo que se tentaram implementar tarefas que promovessem uma aprendizagem ativa, organizando os alunos para o trabalho a pares e utilizando os portfólios digitais como estratégias de ensino. Assim, procuramos perceber se as estratégias adotadas permitiram atingir os objetivos enunciados para a UC, usando uma perspetiva metodológica de investigação-ação, numa tentativa de melhoria contínua da UC e tendo como objeto de análise as reflexões individuais produzidas pelos estudantes, no final da UC.

Para atingir o objetivo desejado, organizou-se este texto começando com esta introdução, segue-se a contextualização onde se descreve a prática pedagógica utilizada, um quadro teórico que permitirá perceber o que se entende por portefólio digital e aprendizagem ativa, a metodologia utilizada e os instrumentos de recolha de dados, a análise dos dados recolhidos e umas notas finais.

Contextualização

A UC em análise integra a oferta curricular da Licenciatura em Educação Básica, possui 48 horas de contacto e é oferecida no primeiro semestre do segundo ano deste curso. No ano letivo em estudo, estiveram matriculados na UC sessenta e oito estudantes, cinco dos quais estavam em mobilidade pelo programa ERASMUS.

A distribuição por género dos estudantes era muito desequilibrada, com enorme prevalência do género feminino, característica comum nos cursos de formação de educadores de infância e de professores de 1.º e 2.º ciclo. Neste ano havia dois estudantes do género masculino, o que corresponde a 3% da população.

Esta UC tem como principais objetivos: Identificar potencialidades, limitações e implicações das TIC (i) o desenvolvimento de capacidades de comunicação síncrona e assíncrona (ii) Demonstração de competência na utilização das TIC (iii) Desenvolvimento de competências de comunicação, oral e escrita; (iv) Conceção, produção de apresentações multimédia visando contextos específicos e (v) Planeamento e preparação de pequenos projetos com apoio de programas específicos.

No fundo, pretende-se que os estudantes reflitam sobre as potencialidades de algumas das ferramentas tecnológicas e que as usem de forma crítica, diminuindo o tempo que despendem com tarefas específicas no seu trabalho enquanto estudantes e, no futuro, enquanto profissionais.

Ao longo do semestre, foram propostas aos estudantes 10 tarefas, maioritariamente, desenvolvidas em grupos de dois. Apenas a última tarefa, a análise reflexiva do seu percurso na UC, era desenvolvida individualmente. Cada tarefa era apresentada pelo professor em sala de aula e tinha associada uma série de recursos, como textos ou vídeos que permitiam aos estudantes alguma autonomia, para explorar ou aprofundar os conhecimentos necessários à sua realização. As tarefas implicavam o desenvolvimento de atividades práticas, com recurso ao computador, iniciadas em sala de aula, onde eram acompanhadas pelos professores e, com alguma frequência, terminadas posteriormente, sendo estabelecido que teriam de ser terminadas na semana em que eram propostas.

Neste contexto, o professor teve um papel muito interventivo na seleção de recursos e na construção dos desafios. Durante o desenvolvimento das atividades, pelos estudantes, teve fundamentalmente um papel de tutor acompanhando os trabalhos dos grupos e intervindo, sempre que era necessário reencaminhar esse trabalho.

No início do semestre, os estudantes construíram a ferramenta que serviria de suporte ao seu portefólio digital para o que foi sugerida a utilização da plataforma *blogger*. A opção por um blogue justifica-se por ser um instrumento de fácil utilização, que pode ser configurado, de acordo com as opções do próprio estudante e que é criado com as suas credenciais, o que o torna um espaço que pode ser utilizado para além do tempo de permanência na Instituição de Ensino Superior. No espaço Moodle dedicado à UC, foram partilhados os endereços dos blogues criados por cada um dos grupos, o que permitiu que qualquer estudante pudesse consultar as atividades e reflexões dos colegas, assim como os *feedbacks* fornecidos pelos professores.

No final de cada tarefa, os estudantes publicavam o trabalho desenvolvido no portefólio digital. Cada uma dessas publicações era acompanhada de um breve texto, publicado a pares ou individualmente, onde os estudantes refletiam sobre a aprendizagem efetuada e sobre as dificuldades sentidas no desenvolvimento da atividade.

Cada publicação deixada no portefólio recebia um *feedback* qualitativo do professor. Este *feedback* era também publicado no portefólio, sobre a forma de um comentário à postagem que os alunos tinham feito, e devia ser fornecido antes dos estudantes iniciarem a atividade seguinte. O cumprimento destes prazos pelo professor nem sempre foi conseguido.

As tarefas propostas problematizavam situações que os estudantes teriam de resolver, sendo algumas com temas escolhidos pelos próprios.

Tabela 1
Software utilizado

Software utilizado	Potencialidades exploradas
Blogues	Construção do blogue que suportaria o portefólio digital
Processador de texto	Utilização de estilos e construção automática de índices
Processador de texto	Estrutura de documentos longos, cabeçalhos, rodapés, orientação de páginas e índice de legendas
Processador de texto e gestor de referências bibliográficas	Instalação do software (*Zotero*), catalogação de documentos, gestão de bibliografia, citações indiretas e diretas, longas e curtas
Apresentações Eletrónicas	Slide Mestre e gravação de imagem parada e em movimento e gravação de vídeos
Formulários em linha	Construção de formulário com tema escolhido pelos estudantes
Folha de cálculo	Conceitos básicos, organização de dados, construção de gráficos e de tabelas dinâmicas com dados recolhidos na tarefa anterior Este tema terminou com a construção de um relatório destinado à análise dos dados recolhidos pelo formulário usado na tarefa anterior. Para a construção do relatório foram mobilizadas as aprendizagens efetuadas no processador de texto e na folha de cálculo.
	Terminada esta tarefa, os grupos analisaram o relatório produzido por um outro par de colegas e publicaram um comentário no respetivo portefólio.
	Reflexão final

II. Quadro Teórico

Na última década do século passado, os portefólios digitais eram considerados instrumentos tecnológicos com pouca relevância para a aprendizagem. No entanto, progressivamente, foram ganhando importância e são, agora, considerados poderosas estratégias de aprendizagem [1]. Estamos de acordo com a ideia de que os portefólios digitais são "student-owned digital working and learning spaces for collecting, creating, sharing, collaborating, reflecting learning and competences, as well as storing assessment and evaluation" [2]. De facto, o blogue constitui-se como um espaço de que os estudantes são autores e proprietários, onde colocam as atividades desenvolvidas e refletem sobre a sua própria aprendizagem [3]. Os portefólios digitais podem ter múltiplas utilizações, por exemplo, como mostra de materiais para candidatura a um emprego ou divulgação pública dos trabalhos de um artista mas, de acordo com as referências [4] - [5], o aspeto reflexivo é fundamental na utilização de portefólios e constitui-se como uma oportunidade de tomar consciência e a utilização do *feedback* dado pelo professor ou pelos pares, constitui um processo de regulação da aprendizagem e mantém os estudantes focados, mesmo quando ocorre algum desvio [6].

Quando os portefólios digitais estão online e acessíveis a estudantes, colegas de turma e professores, a comunicação estudante-estudante e estudante-professor fica facilitada, o que permite que os estudantes usem instrumentos digitais para alargar as suas perspetivas e enriquecer a sua aprendizagem, pela partilha com outros e mesmo pela possibilidade de efetiva colaboração [3], [7]–[9].

Assim, os portefólios envolvem os estudantes numa troca sucessiva de dar (entrega de produções) e receber (*feedback* do professor ou dos colegas) [10] e "colocam o professor na retaguarda da orquestra e os estudantes na primeira fila" [1, p. 87], organização típica dos ambientes construtivistas de aprendizagem, onde o estudante está no centro do processo de aprendizagem e o professor tem, fundamentalmente, o papel de construir ambientes de aprendizagem desafiadores e acompanhar a evolução do estudante [11] .

Aprender através da problematização e da resolução de problemas, na área de interesse dos estudantes, é uma das possibilidades de envolvimento ativo no seu processo de formação [12].

Os autores da referência [13, p. 19] definem aprendizagem ativa como sendo "instructional activities involving students in doing things and thinking about what they are doing", conceito que nos parece em tudo semelhante à estratégia dos portefólios digitais que utilizamos. Os mesmos autores referem ainda que a tipologia de atividades desenvolvidas pelos estudantes pode ser muito diversa, desde as mais simples, por exemplo fazer uma pausa numa aula expositiva para que os estudantes possam discutir entre si os conteúdos abordados, até outras mais complexas.

Esta definição não é única. Mas a ideia dos estudantes desenvolverem esforços para construir o seu conhecimento [14] é a mais comum quando se pretende caracterizar a aprendizagem ativa, associada a trabalho entre estudantes nas aulas ou depois delas, fazer apresentações, colocar questões ou contribuir para discussões e participar em projetos.

Trata-se de uma prática construtivista com ênfase na contribuição da interação social. A relação entre o processo de aprendizagem e a interação com o outro, foi descrita por Lev Vygotsky que enunciou a teoria sociocultural do desenvolvimento [15] onde advoga que a aprendizagem ocorre quando os estudantes resolvem problemas com o suporte do professor ou dos seus pares.

No entanto, o papel do professor é muito importante porque não pode admitir que os estudantes aprendem sozinhos, sem suporte teórico e sem apoio dos pares e do professor [16]. Assim, os recursos disponibilizados têm um papel determinante que, associados a atividades desafiadoras, podem contribuir para um ambiente de aprendizagem rico [17]. A estratégia de colocar os alunos a trabalhar a pares sustenta-se nesta ideia de aprendizagem entre estudantes. O trabalho de apoio do professor e o desenho de ambientes de aprendizagem motivadores são também aspetos muito relevantes para a aprendizagem dos estudantes [18], [19].

III. METODOLOGIA

O estudo realizado possui natureza qualitativa [20] porque se pretende estudar um fenómeno natural no ambiente em que decorreu, tentando perceber o que ocorreu e como ocorreu, Pensamos que o trabalho se enquadra no método de investigação-ação, que se caracteriza pela reflexão sobre a prática e pela procura da mudança, construído por meio de um processo sequencial de experiências desenvolvidas num movimento cíclico, em espiral [21]. De acordo com a referência [22], este método procura implementar soluções que promovam a melhoria da ação, num ambiente de colaboração social, que leve à mudança. Esta caracterização enquadra-se no nosso objetivo: perceber se os objetivos da UC foram conseguidos e o que se poderá alterar para que o seu funcionamento melhore.

Os dados recolhidos na investigação-ação podem ser de três tipos distintos: observação, interação e documentais [23]. No presente caso, os dados em análise foram recolhidos através de reflexões produzidas pelos estudantes, no final da UC. Nestas reflexões, foi sugerido aos estudantes que referissem os seguintes tópicos:

- Expectativas em relação à disciplina;

- Contributos da disciplina para a formação pessoal, académica e profissional;

- Aprendizagens significativas;

- Aspetos globalmente menos conseguidos;

- Sugestões de aprofundamento temático.

Dos sessenta e oito estudantes inscritos na UC, dez reprovaram na avaliação contínua por terem uma frequência irregular ou inexistente e dos restantes cinquenta e oito estudantes, foi possível analisar cinquenta e duas reflexões.

As reflexões foram objeto de análise de conteúdo, onde se procurou encontrar padrões nos discursos dos estudantes, ou expressões que indiciem disrupção [24]. A codificação de dados qualitativos foi efetuada em dois ciclos. Num primeiro ciclo, as categorias de análise foram atribuídas aos dados recolhidos, e num segundo ciclo de análise as categorias iniciais foram reajustadas ou mesmo unidas [25].

No caso deste estudo, as categorias de análise foram construídas, inicialmente, a partir dos tópicos sugeridos pelos professores para construção das reflexões, mas, ao longo do processo de categorização, foram enriquecidas de acordo com os discursos das estudantes. O processo de categorização foi desenvolvido com base no software *TAGUETTE*.

IV. ANÁLISE DOS DADOS RECOLHIDOS

Procurando analisar as aprendizagens reveladas pelos estudantes, criamos a perceção que todas as atividades originaram aprendizagens, apesar da sua importância ser diferente e com opiniões diversas.

As expectativas iniciais dos estudantes podem ser organizadas em três grandes grupos:

1) os que pensavam já saber tudo sobre os temas que iam ser tratados, porque tinham frequentado disciplinas semelhantes no ensino secundário "Primeiramente, acreditava que já conhecia tudo sobre a formatação de textos, as citações e as referências e o Excel. Expressões e Tecnologias surpreendeu-me pela positiva, apercebi-me que afinal não dispunha de tanto conhecimento como pensava." (Estudante 1);

2) as que sentiam receio e insegurança pelas suas fracas competências tecnológicas "Quando começamos as aulas desta unidade curricular estava um pouco apreensiva pois tenho bastantes dificuldades no que toca a área da tecnologia" (Estudante 48);

3) e as que consideram que a UC lhes daria instrumentos para a sua futura profissão "[…] ferramentas a nível tecnológico que apresentassem um caráter didático e lúdico e que permitissem ao público infantil com quem terei o prazer de trabalhar futuramente de abordar as temáticas e conteúdos essenciais previstos no programa através das tecnologias." (Estudante 40).

Apesar das diversas expectativas expressadas pelos estudantes, no final da UC, foram muito frequentes as afirmações de que foram realizadas aprendizagens algo surpreendentes "apesar de estar familiarizada com muitas das ferramentas ao longo do meu percurso académico, pude adquirir mais conhecimentos que facilitaram o desenvolvimento de diversos trabalhos ao longo deste semestre." (Estudante 24).

Quanto ao processador de texto, a maioria dos estudantes tinha expectativas muito baixas por considerarem que era um programa que utilizavam fluentemente. No entanto, houve referências à aprendizagem dos estilos e da construção automática de índices, da legendagem das figuras e tabelas e respetivos índices, da estrutura dos documentos longos, e vários cabeçalhos e numerações de páginas num mesmo documento. "Primeiramente, acreditava que já conhecia tudo sobre a formatação de textos, as citações e as referências e o Excel. Expressões e Tecnologias surpreendeu-me pela positiva, apercebi-me que afinal não dispunha de tanto conhecimento como pensava.” (Estudante 1).

O processador de texto e a folha de cálculo foram os utilitários que os estudantes reconheceram maior utilidade “Aprendi imensas coisas do word e do excel que nunca tinha aprendido e que me vai ajudar muito, principalmente no tempo dispensado para os trabalhos, pois as ferramentas novas que o professor nos ensinou poupam-nos imenso tempo e trabalho, mas principalmente ajudam a estruturar melhor os nossos trabalhos.” (Estudante 1).

Grande parte dos estudantes não revelava competências de utilização da folha de cálculo e consideraram que foi o programa mais complexo e no qual tiveram mais dificuldades. Apesar disso, consideram ter efetuado aprendizagens significativas, nomeadamente sobre a organização de dados e a sua análise com recurso a tabelas dinâmicas e gráficos.

As referências ao software de gestão de referências bibliográficas usado, o *Zotero*, não são unânimes: alguns consideram que facilita a gestão da bibliografia, mas outros consideram que não ficaram com conhecimentos suficientes para dela tirarem partido.” A plataforma *Zotero* permite-nos fazer citações e referências bibliográficas. Nunca tinha ouvido falar, e para mim foi uma aprendizagem muito relevante e precisa, que já devia ter sido falada há mais tempo.” (Estudante 30). Pensamos que o facto de uma das aulas dedicadas a este utilitário ter sido um dia de greve dos transportes e, consequentemente, ter poucos alunos em aula, poderá ter sido a razão para que alguns problemas de utilização deste utilitário não tivessem ficado bem resolvidos.

A organização da formação foi referida como um aspeto positivo por muitos estudantes e valorizaram particularmente o trabalho continuado ao longo do semestre com *feedbacks* parciais, sem testes ou exames.

A utilidade do blogue, que deu suporte ao portefólio digital, não foi entendida nas primeiras sessões, por ser completamente diferente do que tinham feito até então, mas, no final da UC, os estudantes revelam vários aspetos positivos, nomeadamente os relacionados com a reflexão sobre as suas aprendizagens e a disponibilidade das atividades que foram fazendo, assim como as aprendizagens que foram efetuando “Repito que, a utilização dos blogues em contexto educativo sustenta diversas estratégias de ensino e de aprendizagem que vão ao encontro das necessidades dos alunos, uma vez que proporcionam uma aprendizagem significativa que potencia o alcance de bons resultados escolares.“ (Estudante 23).

A exigência de uma reflexão, após o fim de cada atividade, foi considerada muito útil para a aprendizagem, mas simultaneamente um grande desafio:

> Considero que fazer as reflexões das atividades executadas em aulas todas as semanas no blog foi um grande desafio para mim, pois tenho bastante dificuldade em conseguir escrever de forma objetiva tudo o que realizamos, pois tenho muita dificuldade no que diz respeito à parte escrita. (Estudante 48)

e a liberdade concedida na edição e formatação do blogue foi também um aspeto valorizado:

> Na minha opinião, a criação de um blogue, foi uma das tarefas que mais gostei, para além de termos a liberdade de editar o blogue à nossa imagem, foi um dos métodos de avaliação mais diferenciado. Como alunos, estamos habituados a fazer testes e/ou trabalhos de grupo, assim de forma simples e rápida podemos atualizar as nossas publicações, visando sempre as tarefas feitas na aula e a nossa reflexão, conseguimos também observar o nosso progresso nesta disciplina. (Estudante 17).

Foi também muito valorizado o papel dos professores referidos como “A minha opinião final é que […] aprendi bastante, valorizando-a por ser prática, e pela abordagem do professor para com as explicações e apoio dado dentro e fora das aulas.” (Estudante 8) ou ainda “Para que a realização de todas as tarefas fosse bem sucedida, tanto eu como o meu par de trabalho, recorremos inúmeras vezes à docente para o esclarecimento de dúvidas.” (Estudante 23).

Em sentido oposto, referem que a unidade curricular foi bastante trabalhosa, mas que permitiu que uma parte substancial do trabalho fosse feita na sala de aula, excetuando-se as reflexões que muitas vezes eram desenvolvidas em casa.

O carácter eminentemente prático da UC foi do agrado dos estudantes e os recursos associados às tarefas foram muito úteis, quando tinham dúvidas no desenvolvimento das atividades “tenho utilizado o Word segundo as recomendações desta UC, e às vezes vou consultar ao moodle se estou a fazer bem ou não, ou como deveria ser feito.” (Estudante 4).

A UC foi organizada com os estudantes a trabalharem em grupos de dois, ou seja, cada par usava o mesmo computador e construíam os seus portefólios, usando o mesmo blogue. Esta organização a pares é referida, por quase todos os estudantes, fundamentalmente, como um aspeto positivo, porque podiam desenvolver um trabalho colaborativo, discutindo o desenvolvimento das atividades e promovendo aprendizagens significativas entre ambos. “Os trabalhos serem feitos a pares acho que é uma forma vantajosa de aprendizagem pois podem ser discutidas opiniões variadas, dúvidas e explicações, mencionando também que conseguimos completar os trabalhos propostos pelo professor com uma maior rapidez e eficácia” (Estudante 42). No entanto, há também 3 referências negativas ao trabalho a pares, onde houve desistências de estudantes ou um envolvimento muito desequilibrado nos trabalhos.

O nosso ponto de partida deste estudo era perceber se os objetivos desenhados para esta unidade curricular tinham sido atingidos. Parece-nos que a UC teve sucesso e a reflexão desta aluna resume bem este aspeto:

> Em relação às competências adquiridas ao longo do semestre, reporto que tiveram um grande impacto no decorrer de outros trabalhos académicos e serão bastante enriquecedoras para o meu futuro profissional. Assim as tarefas realizadas nesta UC permitiram aprofundar os meus conhecimentos em relação a vários programas de software, melhorar o meu pensamento crítico e

reflexivo, e estimular o meu sentido de cooperação. (Estudante 48).

A frequência das UC, por estudantes de ERASMUS, é sempre um desafio para professores e, apesar de não ser o objetivo deste estudo, a reflexão desta estudante, de nacionalidade espanhola, parece-nos muito significativa e por isso a transcrevemos.

> También tengo que decir que las expectativas en torno a esta asignaturano eran muy buenas, debido a que no conocíasu contenido, pero a lo largo del semestre me he dado cuenta de que,si me ha ido gustando poco a poco, aunque durante ella he tenido algunas dificultades, pero eso no me ha llevado a rendirme, si no a ser capaz de levantarme y acabar una asignatura junto con mi compañera de la mejor manera posible. Ha sido un gran placer pertenecer a esta aula y haber aprendido tanto con ella. Esta como muchas de las que he ido realizando en el Erasmus han sido super importantes para mí. Me voy a España super satisfecha de todo lo aprendido aquí y de todo lo que me queda por aprender. (Estudante 35).

No que se relaciona a sugestões para futuras ocorrências desta UC, a única que foi registada com bastante frequência relaciona-se com a sua passagem para o 1.º ano do curso: "a meu ver é uma UC bem estruturada e com todos os objetivos definidos. É uma UC muito útil, penso que deveria haver no primeiro ano de licenciatura para nos ajudar na realização dos trabalhos." (Estudante 52).

Notamos ainda um aspeto que nos parece relevante e que se relaciona com a consulta dos portefólios dos colegas. Nas reflexões não existe nenhuma referência à consulta dos trabalhos desenvolvidos pelos colegas, o que nos parece estranho por considerarmos que podia ser um aspeto promotor de aprendizagens.

V. NOTAS FINAIS

Embora nem sempre houvesse unanimidade na opinião dos estudantes, a maioria reconheceu a relevância desta UC no seu percurso académico, nomeadamente no que se refere à formatação e apresentação de trabalhos académicos e na gestão de bibliografia. O reconhecimento da importância desta UC foi traduzida no pedido realizado pelos estudantes, onde sugeriram que existisse uma mudança da mesma para o 1.º semestre da licenciatura, na perspetiva de facilitar a construção dos relatórios, desde o início do curso.

O trabalho, em pequeno grupo, funcionou bem em quase todas as situações e permitiu que os estudantes se entreajudassem, em linha com as reflexões enunciadas por Vigotsky [15].

A utilidade do portefólio digital não foi percecionada pelos estudantes no início da UC, mas depois foi reconhecido o seu papel, nomeadamente no que se refere aos contributos da reflexão para aprendizagens significativas [2]-[4]. Consideramos também que a liberdade dada aos estudantes para formatarem o portefólio foi bastante valorizada por eles e contribuiu para o desenvolvimento do sentido de propriedade e autoria [10][11].

O papel dos professores foi bastante valorizado, quer pelo *feedback* atempado às publicações no portefólio, quer pelo papel de tutor desempenhado ao longo das aulas [17][18].

Os estudantes referem o caráter prático da UC como um aspeto positivo [12] que se relaciona não só com a organização do trabalho, em pequeno grupo, com o objetivo de promover a aprendizagem entre pares [14][15], mas também com a metodologia ativa adotada, onde a resolução das tarefas e a reflexão sobre elas promoveram aprendizagens significativas.

Pensamos, pois, que, embora haja sugestões que podem ajudar a melhorar a prática letiva da UC, de um modo geral, na perspetiva dos estudantes que a frequentaram este ano, os objetivos traçados foram alcançados.

No que se relaciona com a mudança da UC para o primeiro ano do plano de estudos, os docentes efetuaram a proposta à Coordenação de Curso, que se mostrou recetiva à ideia. No entanto, os constrangimentos legais, relativos ao modelo de formação de professores, poderá ser um entrave a esta alteração.

REFERÊNCIAS

[1] R. Z. Prokopetz, «A Reflection Upon Capstone ePortfolio Projects and Their Alignment With Learning Theories», *International Journal of ePortfolio*, vol. 12, n.º 1, pp. 1–5, 2022.

[2] I. Kunnari, M. Laurikainen, A. L. O. Pires, e M. do R. Rodrigues, «Supporting students' ePortfolio process in Higher Education», *HAMK Unlimited Journal*, 2017, Acedido: 28 de janeiro de 2022. [Em linha]. Disponível em: https://unlimited.hamk.fi/ammatillinen-osaaminen-ja-opetus/supporting-students-eportfolio-process-in-higher-education/

[3] M. do R. Rodrigues, A. L. O. Pires, e J. Pinto, «Utilização de portefólios digitais na formação inicial de professores, como estratégia de aprendizagem e avaliação: perspetivas das estudantes», *Revemop*, vol. 4, pp. 1–16, 2022, doi: 10.33532/revemop.e202209.

[4] H. C. Barrett, «Researching Electronic Portfolios and Learner Engagement: The REFLECT Initiative», *Journal of Adolescent & Adult Literacy*, vol. 50, n.º 6, pp. 436–449, 2007, doi: 10.1598/JAAL.50.6.2.

[5] T. Dune, K. Crnek-Georgeson, J. Bidewell, R. Firdaus, J. John, e A. Arora, «Undergraduate health science students' development of reflective practice on communication skills via e-Portfolios», *Journal of University Teaching & Learning Practice*, vol. 15, n.º 3, set. 2018, doi: 10.53761/1.15.3.5.

[6] D. Wiliam, «Feedback: Part of a System», *Educational Leadership*, vol. 70, n.º 1, pp. 30–34, set. 2012.

[7] «ISTE Standards: Students», 2022. https://www.iste.org/standards/iste-standards-for-students (acedido 11 de julho de 2023).

[8] M. Lucas e A. Moreira, *DigCompEdu: quadro europeu de competência digital para educadores.* Universidade de Aveiro, 2018.

[9] A. W. (Tony) Bates, *Teaching in a Digital Age: Third Edition: Guidelines for designing teaching and learning*. Contact North, 2023. Acedido: 23 de junho de 2021. [Em linha]. Disponível em: https://pressbooks.bccampus.ca/teachinginadigitalagev3m/

[10] T. Rhodes, «Lift every voice: ePortfolios for creating and integrating», *International Journal of ePortfolio*, vol. 8, n.º 2, pp. 87–89, 2018.

[11] S. Papert, *The children's machineThe children's machine: Rethinking school in the age of the computer.* New York: Basic Books, 1993. [Em linha]. Disponível em: https://archive.org/details/pdfy-WeLwkqLL6w830OqF

[12] N. A. N. Berbel, «As metodologias ativas e a promoção da autonomia de estudantes», *Semin. Cienc. Soc. Hum.*, vol. 32, n.º 1, p. 25, mar. 2011, doi: 10.5433/1679-0383.2011v32n1p25.

[13] C. C. Bonwell e J. A. Eison, «Active Learning: Creating Excitement in the Classroom. 1991 ASHE-ERIC Higher Education Reports», ERIC Clearinghouse on Higher Education, The George Washington University, One Dupont Circle, Suite 630, Washington, DC 20036-1183 ($17, 1991. Acedido: 13 de julho de 2023. [Em linha]. Disponível em: https://eric.ed.gov/?id=ED336049

[14] R. Carr, S. Palmer, e P. Hagel, «Active learning: The importance of developing a comprehensive measure», *Active Learning in Higher Education*, vol. 16, n.º 3, pp. 167–236, 2015. doi: 10.1177/1469787415589529.

[15] L. S. Vygotsky, «Mind in society: The development of higher psychological processes», *Mind in Society The Development of Higher Psychological Processes*, vol. Mind in So, p. 159, 1978, doi: 10.1007/978-3-540-92784-6.

[16] S. P. D e R. Kumar, «Effective Constructivist Teaching Learning in the Classroom», *International Journal of Education*, vol. 7, n.º 4, 2019, Acedido: 13 de julho de 2023. [Em linha]. Disponível em: https://papers.ssrn.com/abstract=4004512

[17] A. D. Figueiredo e A. P. Afonso, «Context and Learning: A Philosophical Framework.», em *Managing Learning in Virtual Settings*, Hershey: Information Science Publication, 2006, pp. 1–23. [Em linha]. Disponível em: http://old.igi-global.com/downloads/excerpts/Figueiredo01.pdf

[18] J. Filgona, J. Sakiyo, D. M. Gwany, e A. U. Okoronka, «Motivation in Learning», *Asian Journal of Education and Social Studies*, pp. 16–37, set. 2020, doi: 10.9734/ajess/2020/v10i430273.

[19] F. A. Costa, J. Viana, T. Trez, C. Gonçalves, e E. Cruz, «Desenho de atividades de aprendizagem baseado no conceito de aprender com tecnologias», em *Challenges 2017: Aprender nas nuvens, learning in the clouds: Atas da X Conferência Internacional de Tecnologias de Informação e Comunicação na Educação*, M. J. Gomes, A. Osório, e L. Valente, Eds., Braga: Centro de Competência da Universidade do Minho, 2017, pp. 409–423. [Em linha]. Disponível em: https://www.nonio.uminho.pt/wp-content/uploads/2020/09/atas_chalenges_2017.pdf

[20] J. Amado, *Manual de Investigação Qualitativa em Educação 3ª edição*. Coimbra: Imprensa da Universidade de Coimbra / Coimbra University Press, 2017.

[21] A. Moreira, P. Sá, e A. P. Costa, Eds., *Reflexões em torno de Metodologias de Investigação - métodos*, vol. 1. Universidade de Aveiro, 2021.

[22] C. P. Coutinho, «Paradigmas, Metodologias e Métodos de Investigação», *Metodologia de Investigação em Ciencias Sociais, Teoria e Prática*, pp. 9–41, 2011.

[23] C. P. Coutinho, *Metodologia de Investigação em Ciências Sociais e Humanas: Teoria e Prática*, 2.ª edição. Coimbra: Almedina, 2013.

[24] L. Bardin, *Análise de Conteúdo*. Lisboa: Edições 70, 2004.

[25] M. B. Miles, A. M. Huberman, e J. Saldana, *Qualitative Data Analysis A Methods Sourcebook*, Fourth Edition. USA: SAGE Publications, Ltd, 2020.

Reflexões em torno de um projeto de robótica educativa na Educação de Infância e no 1.º Ciclo do Ensino Básico

João Carlos Grácio
Escola Superior de Educação
Instituto Politécnico de Setúbal
Setúbal, Portugal
joao.gracio@ese.ips.pt

João Torres
Escola Superior de Educação
Instituto Politécnico de Setúbal
Setúbal, Portugal
joao.torres@ese.ips.pt

Maria do Rosário Rodrigues
Escola Superior de Educação
Instituto Politécnico de Setúbal
Setúbal, Portugal
rosario.rodrigues@ese.ips.pt

Ana Chambel
Escola Superior de Educação
Instituto Politécnico de Setúbal
Setúbal, Portugal
ana.chambel@ese.ips.pt

Miguel Figueiredo
Escola Superior de Educação
Instituto Politécnico de Setúbal
Setúbal, Portugal
miguel.figueiredo@ese.ips.pt

***Abstract*— Com este texto pretende-se refletir sobre o desenvolvimento de um projeto de utilização educativa de robótica, nos primeiros anos, que culminou com o desafio da participação num concurso internacional, MatataWorld Robotics Competition (MWRC) tentando perceber o seu sucesso. Utilizou-se uma metodologia de estudo de caso onde os dados analisados são as avaliações e reflexões dos professores e o material submetido a concurso. Participaram turmas do pré-escolar e do 1.º ciclo do Ensino Básico neste projeto que contou com o apoio da MatataStudio, uma empresa de tecnologia educativa, sendo também a promotora do concurso MWRC. Reconhecemos que a participação das escolas no projeto foi muito positiva, e que a participação de professores e educadores no concurso internacional promoveu a utilização educativa da robótica, sendo também uma oportunidade para que se criasse uma comunidade online.**

Keywords*— Robótica educativa, formação de professores e educadores, comunidades de prática.

I. Introdução

O Projeto MatataStudio teve o seu início no ano letivo 2021/22 e surgiu de uma parceria entre a Direção-Geral da Educação (DGE), a European Schoolnet (EUN) e a empresa MatataStudio. Neste projeto internacional, colaboraram ativamente seis países da União Europeia: Portugal, França, Dinamarca, Noruega, República Checa e Eslováquia.

Em Portugal, o Centro de Competência TIC da Escola Superior de Educação do Instituto Politécnico de Setúbal (CCTIC-ESE/IPS) assumiu este projeto, tendo convidado o Agrupamento de Escolas Luísa Todi, em Setúbal, para o integrar. Desta forma, estiveram envolvidas no projeto seis turmas do pré-escolar e do 1.º Ciclo do Ensino Básico (CEB) de duas escolas daquele Agrupamento.

Os objetivos do projeto, nesse ano, eram:

- Levar os alunos a explorar os kits de robótica MatataStudio: Tale-Bot e Coding Set;

- Levar os educadores/professores a construir planos de aula, utilizando pedagogicamente os robôs para a aprendizagem;

- Levar os alunos a participar na testagem desses planos de aula, construídos pelos educadores/professores;

- Promover a utilização pedagógica destas ferramentas de aprendizagem da programação;

- Partilha de planos de aula entre os vários países envolvidos no projeto.

Como conclusão de todo o projeto, a Direção Geral de Educação (DGE) realizou, em maio de 2022, um *webinar* de apresentação do mesmo e das atividades desenvolvidas no seu âmbito, com a apresentação dos planos de aula construídos e das experiências de implementação em sala de aula.

No seguimento de todo este trabalho realizado, durante o ano letivo 2021/22, pensamos, no início do ano letivo 2022/23, que poderíamos desenvolver estas atividades em mais agrupamentos da nossa área de influência.

Assim, contactamos a empresa MatataStudio, para ver qual seria o seu interesse e disponibilidade e, após uma primeira reunião, em que a resposta foi afirmativa, construímos e assinamos um protocolo para que o projeto pudesse vir a ser uma realidade. Para além do desenvolvimento das atividades com os professores, foi também acordado que seria desenvolvido, em Portugal, um concurso com todas as turmas envolvidas no projeto, à semelhança de outros concursos que haviam sido dinamizados pela empresa, em outros países.

Após esta primeira fase, entramos em contacto com onze agrupamentos de escolas do ensino público e uma escola privada, sendo que dez, dos onze agrupamentos, mostraram interesse em participar no projeto, assim como a escola privada. O nosso objetivo seria ter um mínimo de 20 participações no concurso, o que equivale a uma participação média de duas turmas por agrupamento. Conseguindo este objetivo, teríamos conseguido também implementar práticas de uso de robótica educativa no pré-escolar e 1.º CEB dos vários agrupamentos envolvidos.

Estabelecemos, assim, um memorando de entendimento, entre o Instituto Politécnico de Setúbal (IPS) e cada uma das escolas envolvidas, onde era definido o que ambas as partes se comprometiam a fazer, sendo que o IPS ficou responsável pela formação de professores, pelo empréstimo de dois robôs por agrupamento para o desenvolvimento das atividades, e pelo acompanhamento dos professores, relativamente à participação na Competição Internacional de Robótica (MWRC Portugal). As escolas/agrupamentos comprometeram-se a definir um grupo de professores (mínimo de 3 e máximo de 10 elementos) que participassem na formação de professores e na Competição Internacional de Robótica (MWRC Portugal), com a integração mínima de duas turmas (1 turma do Pré-escolar e outra do 1.º CEB) no concurso.

Esta parceria foi estabelecida por um ano, com o seu término em dezembro de 2023.

Este texto constitui-se como uma oportunidade de perceber o sucesso da iniciativa, não só analisando e refletindo sobre os percursos dos professores, mas também pela interpretação da sua adesão ao concurso. Para isso apresentaremos as atividades desenvolvidas, até ao momento, no âmbito do projeto e refletiremos sobre o *feedback* dos participantes relativamente à formação ministrada e às interações que se estabeleceram entre os participantes, através da plataforma *Moodle*, numa disciplina criada para acompanhar o projeto.

Apresentaremos uma contextualização teórica, seguida de uma descrição da metodologia adotada para a pesquisa, assim como a análise que realizamos, a partir dos dados obtidos e a apresentação dos respetivos resultados. Finalmente, apresentaremos algumas conclusões, que nos serão úteis, adaptando metodologias e procedimentos, em futuros projetos que venhamos a desenvolver.

II. ENQUADRAMENTO TEÓRICO

Nos últimos anos, uma das áreas de formação em que tem existido um interesse crescente, por parte dos professores, é a robótica educativa. Este facto está relacionado, de acordo com os pedidos que nos chegam, com a necessidade de abordar as aprendizagens essenciais, das diferentes disciplinas, de forma mais lúdica e motivante.

Esta ideia da motivação para a aprendizagem é defendida por Rodrigues & Felício [1], quando afirmam que o trabalho com os robôs é muito motivador para as crianças, uma vez que as mesmas se envolvem com alegria nas atividades, procurando resolver os desafios com sucesso. De acordo com os mesmos autores, "Even among usually more difficult children who place little value on school and work of the teacher, who often have very little interest in the lessons and activities developed, the motivation, interest and commitment were visible." (p. 110).

Para além desta questão da motivação dos alunos, em relação à aprendizagem, vários autores têm vindo a realçar o papel que a robótica educativa pode desempenhar no desenvolvimento de competências, por parte dos alunos.

Se, num primeiro momento, a robótica educativa apareceu muito ligada às disciplinas de carácter mais técnico, numa perspetiva de disciplina tecnológica por si própria, que merece uma abordagem autónoma, nos últimos tempos passou a utilizar-se "em contextos escolares que vão do jardim-de-infância, à conceptualização e construção de teatros e danças robóticas, à utilização em contextos de aprendizagem de matemática, de física ou de conceitos ligados à programação, à automação e domótica." [2].

De facto, estes projetos, que se vão realizando, não têm como objetivo único o domínio da programação e da robótica, numa perspetiva mais técnica, mas sim o seu uso como potenciador de melhores aprendizagens, por parte dos alunos [2].

Para Pedro, Matos, Piedade & Dorotea [3], a robótica educativa "permite tornar tangíveis os conceitos ligados à programação e ao pensamento computacional" (p. 16).

Segundo Pereira Matos & Ramos [4], a robótica educativa pode levar os alunos a "Aprender a criar, aprender a planear, aprender a resolver problemas, aprender a programar ligando artefactos tangíveis, construindo algo com uma finalidade, proporcionando também a articulação com conteúdos das diferentes áreas do saber (…)" (p. 3).

De acordo com Ramos [5], "Um dos pontos fortes da utilização da robótica é incentivar os alunos a trabalhar em grupo, estimulando a comunicação, o pensamento crítico, a resolução de problemas, entre outras competências previstas no Perfil do Aluno à Saída da Escolaridade Obrigatória" (p. 36), preparando os alunos para o seu futuro profissional.

Para Tadeu, Brigas, Pereira & Arziev [6], as atividades com robótica "tend to allow children to discover answers for themselves rather than just receiving solutions or algorithms to follow; that is, a constructivist approach is encouraged; promote students to realize that they are able to find solutions to problems on their own rather than receiving a solution to apply to the problem." (p. 117).

Assim, a utilização da robótica educativa, na sala de aula, pode tornar o processo educativo mais dinâmico, consistente, interativo e participativo, capacitando os alunos para o uso de novas ferramentas que mobilizam várias dimensões do saber, do saber fazer e do saber estar, através da criação de situações de aprendizagem ativa e interdisciplinar.

Para além destas questões, existe ainda outra que é extremamente importante e que está relacionado com o papel do erro. A depuração (debugging), relacionada com a resolução de problemas, envolve exploração, observação, comunicação e reflexão e pode ser trabalhada, de forma lúdica, levando os alunos a imaginar, enquanto desenvolvem a resolução dos problemas [7].

Desta forma, o trabalho realizado com a robótica pode permitir que os alunos: i) conheçam um problema, procurem e selecionem conhecimentos prévios para tomar uma decisão; ii) estabeleçam relações, em vez de abordarem isoladamente alguns conteúdos; iii) trabalhem coletivamente para alcançar uma solução para o problema proposto; iv) cooperem, de forma a chegar a um consenso; v) explicitem o seu próprio pensamento e tentem compreender o pensamento do outro; vi) discutam dúvidas e ideias; vii) incorporem soluções alternativas, estruturando e ampliando a compreensão sobre os conceitos envolvidos nas situações e viii) criem situações em que precisam de desenvolver algum tipo de estratégia para as resolver [8].

No entanto, todo este tipo de trabalho só fará sentido se o professor adotar "metodologias e estratégias de trabalho que proporcionem aos alunos a oportunidade de analisarem, investigarem, experimentarem e proporem soluções para problemas concretos." [3, p. 23]. Os mesmos autores sugerem a adoção de "metodologias de aprendizagem ativas e colaborativas que privilegiam a participação dos alunos, a articulação de saberes, a colaboração, o pensamento crítico, a resolução de problemas, o raciocínio lógico, a partilha e a comunicação." (p. 23).

Em suma, são muitas as vantagens trazidas pela robótica ao processo de ensino e aprendizagem. No entanto, tudo vai depender do ambiente educativo utilizado pelo professor, da intencionalidade com que é feito o desenho das atividades e dos cenários de aprendizagem que serão desenvolvidos com os alunos.

Para além dos aspetos da robótica educativa para o desenvolvimento do projeto foi também relevante a participação dos professores numa comunidade de prática sustentada pelo *Moodle*. De facto, as comunidades de prática (Comunity of practice – CoP) são formadas por pessoas que partilham de um mesmo interesse ou paixão e que, de forma voluntária, interagem regularmente, trocam informações e conhecimento e partilham aprendizagens [9].

III. Metodologia

Neste ponto descrevemos a metodologia adotada, que inclui o desenho da investigação, os procedimentos utilizados para recolha dos dados e a estratégia de análise de dados utilizada.

O estudo realizado não pretende generalizações dos resultados obtidos, mas procura investigar factos, ideias e descobrir significados nas ações individuais e nas interações sociais, a partir da perspetiva dos atores envolvidos no processo [10], pelo que consideramos que possui uma natureza eminentemente qualitativa [11].

Pretendemos uma descrição e análise detalhada de um sistema limitado à iniciativa MatataStudio, [12] que se entende como uma situação pontual, com características bem definidas [13]. O estudo de caso é um método de investigação muito utilizado nas Ciências Sociais quando se procura o "como?" e o "porquê?" [13], quando se pretende estudar acontecimentos reais e quando o campo de investigação se centra num fenómeno natural, inserido num contexto da vida real. Ao contrário dos estudos experimentais, em que há fatores que podem ser alterados para perceber que efeitos produzem, no estudo de caso os elementos descritivos e interpretativos são mais importantes do que as relações de causa-efeito. A utilização do método de estudo de caso tem como principal objetivo compreender um fenómeno observado com características bem definidas, designado como caso e não requer a intenção de generalizar os resultados obtidos [10].

Assumimos que o estudo de caso tem um pendor eminentemente qualitativo, mas não excluímos a possibilidade de incluir dados de natureza quantitativa [14].

No presente caso, os dados em análise foram recolhidos através do questionário utlizado para avaliação da Ação de Curta Duração (ACD), por recolha dos contributos deixados pelos professores em função das experiências que foram efetuando na sala de aula e finalmente, pelas turmas inscritas nas submissões de trabalhos ao concurso.

Estamos assim, perante um estudo de caso que contempla dados de natureza qualitativa, mas também de natureza quantitativa [15]. Os dados qualitativos são provenientes da interação no fórum e os dados de natureza quantitativa que foram recolhidos através de um questionário utlizado para avaliação da ACD.

Os agrupamentos convidados a participar no projeto foram escolhidos tendo em conta o seu envolvimento no Projeto-Piloto Manuais Digitais, em estreita articulação com o CCTIC-ESE/IPS.

Os dados foram recolhidos ao longo das três fases de desenvolvimento do projeto: avaliação da ACD pelos participantes, participação no *Moodle* e submissão de projetos a concurso. Na fase em que esta análise foi desenvolvida ainda não havia informação sobre a classificação dos projetos pelo júri designado para o efeito.

Mantivemos o anonimato dos professores envolvidos no projeto e, nas referências às suas participações no fórum, foi utilizado um código que corresponde ao atribuído automaticamente pelo *Moodle*.

IV. Análise de Dados

A. *Formação*

Foram realizadas três sessões de formação, durante o mês de janeiro de 2023, distribuídas geograficamente pelo distrito de Setúbal, em agrupamentos envolvidos, de modo a minimizar as deslocações dos professores que frequentaram a formação (ver Tabela 1). Estas sessões contaram com a participação de um total de oitenta e um professores e tiveram por objetivo enquadrar o projeto e fornecer uma primeira abordagem à robótica educativa e, em particular, aos robôs que iriam ser usados na experiência.

Tabela 1 - Local das sessões de formação e número de professores envolvidos

Local da sessão	Data	Nº de professores
Sessão 1 - Quinta do Conde	18/01/23	29
Sessão 2 - Pinhal de Frades	25/01/23	21
Sessão 3 - Setúbal	26/01/23	31
Total		**81**

Foram ministradas por uma equipa de seis docentes, estando, pelo menos, três em cada uma das sessões. As sessões foram constituídas, num primeiro momento, por uma exposição por parte dos formadores, sobre as potencialidades da robótica educativa. Num segundo momento, os formandos realizavam, em grupos, a exploração dos robôs, com o auxílio dos formadores e, num terceiro momento, eram partilhadas, em grande grupo, as descobertas realizadas e eram discutidas algumas dúvidas apresentadas.

No final da sessão, os intervenientes eram convidados a fazer a avaliação das sessões, fazendo-o quantitativamente em relação a seis parâmetros (i) Consecução dos objetivos, (ii) Satisfação das expectativas, (iii) Interação com o Formador, (iv) Clareza exposições, (v) Suporte logístico e (vi) Satisfação global. Cada um destes parâmetros era avaliado na escala de 1 a 5 em que 1 era considerado muito negativo e 5 muito positivo. Avaliaram a formação sessenta professores, 74% daqueles que a frequentaram. Na Tabela 2 podemos ver os resultados quantitativos dessa avaliação.

Tabela 2 - Resultados quantitativos da avaliação da formação

	Sessão A	Sessão B	Sessão C	Média
Consecução dos objetivos	4,79	4,86	4,82	4,82
Satisfação das expectativas	4,67	4,71	4,67	4,68
Interação com o formador	5,00	4,93	4,86	4,93
Clareza exposições	4,91	5,00	4,95	4,95
Suporte logístico	4,58	4,77	4,57	4,64
Satisfação global	4,87	4,71	4,68	4,75
Média	4,80	4,83	4,76	4,80

Todos os parâmetros avaliados estão francamente positivos, destacando-se os valores mais altos relativos à clareza das exposições e à interação com os formadores.

No mesmo questionário havia ainda duas questões abertas onde os formandos poderiam destacar os aspetos mais positivos e os menos bem conseguidos.

Nas questões abertas, os professores destacaram principalmente a oportunidade de contactarem com os robôs que iriam utilizar. Como ponto menos positivo alguns docentes destacaram o pouco tempo disponível, manifestando que gostariam de ter mais tempo de formação que lhes permitisse uma maior exploração dos robôs. Em duas das sessões, onde houve maior número de formandos, alguns destacaram ainda, pela negativa, haver poucos robôs para a exploração.

B. Participação no Moodle

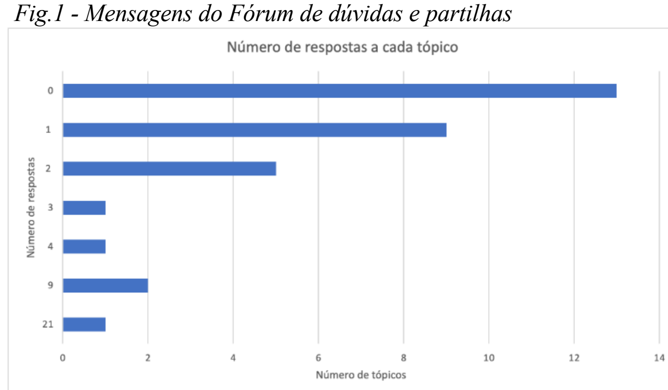
Inscreveram-se na disciplina moodle, de apoio ao projeto, cinquenta e cinco participantes. Destes, seis faziam parte da equipa promotora do projeto, sendo os restantes professores que, nas escolas, implementaram o projeto. Verificamos pelas mensagens submetidas que alguns destes professores inscritos não participavam de forma individual, mas representando um coletivo, de uma escola, por exemplo.

C. Análise das mensagens do Fórum de dúvidas e partilhas

Participaram no fórum vinte e nove professores. Os dois participantes mais ativos, que publicaram vinte e uma e dez mensagens respetivamente, foram os formadores que acompanharam o grupo. Estes dois intervenientes, além do papel de incentivo às partilhas de experiências e esclarecimento de dúvidas, respondiam a muitas das mensagens colocadas pelos restantes elementos [9].

Foram abertos no fórum um total de trinta e dois tópicos e registadas noventa e sete mensagens. A maioria dos tópicos consistia, como sugere o nome do próprio fórum, em partilhas de experiências e pedidos de esclarecimento de dúvidas. O tópico com maior número de respostas obteve 21, tratando-se de uma questão colocada pelos formadores para recolha dos participantes no concurso. Seguiram-se dois tópicos com 9 respostas cada, um referente a dúvidas sobre o envio dos trabalhos e outro com um desafio à partilha das atividades que estavam a ser desenvolvidas (ver Fig.1).

Fig.1 - Mensagens do Fórum de dúvidas e partilhas



A partilha de experiências, como a que transcrevemos abaixo, relata o contexto em que tinha sido realizada e os materiais usados:

> A propósito da Educação Financeira, foi elaborado um tapete e respetivas questões, havendo uma correspondência entre as respostas e as imagens do tapete.
>
> O tapete foi explorado por alunos de 2º, 3º e 4º anos.
>
> Na construção dos percursos foram abordados, entre outros conteúdos, os ângulos e algumas notas musicais e respetivos tempos. (Prof. 1572)

Estes relatos vinham quase sempre acompanhados de fotos e vídeos que mostravam as atividades desenvolvidas, onde era possível ver a riqueza dos materiais elaborados, como tapetes específicos, por exemplo (ver Fig.2), e o envolvimento dos alunos em trabalho de grupo [2][4][5][8].

Fig.2 - *Foto publicada pela Prof. 1222*

Pensamos que muitos colegas se sentiam inspirados pelas partilhas feitas, embora não haja no fórum evidências que nos permitam afirmá-lo. No entanto, sendo o formato vídeo aquele em que seriam realizadas as participações no concurso, estas partilhas de experiências constituíram-se, com certeza, pelo menos, como fator motivacional para a participação no concurso por parte de outras equipas.

Há mesmo uma mensagem que sugere a construção de um repositório de materiais:

"Começo a achar que devíamos criar um repositório de materiais criados com este projeto. Assim poderia aproveitar este recurso de Literacia Financeira." (Mensagem no fórum Prof. 1222)

D. Participação no concurso

O concurso teve como tema "Exploração para uma vida melhor". As equipas efetivavam a participação através do envio de um vídeo. Houve vinte e um projetos submetidos a concurso, envolvendo trinta e um docentes, com doze turmas de 1.º CEB e nove salas de Jardim de Infância. Dos agrupamentos que receberam formação, nove participaram no concurso. O agrupamento que apresentou maior número de projetos, enviou cinco trabalhos. Apenas uma escola, a escola privada, e um agrupamento, não apresentaram trabalhos a concurso.

Os projetos abordaram temas variados: Ambiente, Descobrimentos, Sistema Solar, Alimentação saudável, Energias renováveis e Animais em via de extinção. Nos vídeos e materiais partilhados é visível a criatividade e diversidade de materiais usados para a construção de ambientes de aprendizagem (ver Fig. 3).

Fig.3 – *Exemplo de materiais criados pelos alunos para o ambiente de aprendizagem*

Estes projetos foram analisados por um júri internacional, constituído por quatro elementos, dois do IPS e dois da empresa promotora do concurso. Os critérios de apreciação eram: (i) criatividade, (ii) expressão plástica, (iii) qualidade do código e (iv) qualidade da expressão oral na apresentação dos trabalhos [8]. Os trabalhos eram submetidos em formato vídeo em registos que não ultrapassassem cinco minutos, que deveriam deixar transparecer o envolvimento dos alunos nas atividades e o cumprimento dos critérios de avaliação dos projetos.

Os trabalhos submetidos, após uma análise preliminar, foram considerados de qualidade, quer pelos elementos nacionais do júri, quer pelos representantes da empresa., sendo todos premiados. Existiam prémios para os dois melhores trabalhos (um do pré-escolar e um do primeiro ciclo),Foram distinguidos dois trabalhos: um do pré-escolar e um do primeiro ciclo em cada uma das três primeiras categorias: 1.ª categoria "Shining Star", projetos inspiradores que se destacassem de acordo com todos os critérios de apreciação; 2.º categoria "Coding Star", para os projetos que se destacassem pela qualidade do código; 3ª categoria "Creative Star", para os projetos que se destacassem pela criatividade. Existia ainda uma quarta categoria, "Teamwork Star", para projetos onde o trabalho de equipa estivesse evidenciado.

V. Conclusões

Depois do primeiro ano do projeto, num agrupamento de escolas de Setúbal, o segundo ano, sobre o qual recai a análise deste estudo, pretendia alargar a utilização da robótica educativa nas escolas portuguesas, em particular nas situadas na região de Setúbal. O projeto desenhado tinha por objetivo dar a conhecer o material e incentivar o seu uso, traduzindo-se em contexto educativo, culminando na participação de professores e alunos de escolas portuguesas no concurso internacional promovido pela empresa MatataStudio. O desenho do projeto previa a disponibilização de material, a formação inicial dos professores envolvidos e o seu acompanhamento através de uma comunidade online.

Os dados analisados apontam para o sucesso da iniciativa. Por um lado, houve uma forte adesão dos agrupamentos e escolas convidadas, tendo aceitado participar onze das doze escolas contactadas. Por outro lado, houve uma participação significativa e de qualidade no concurso, por parte de nove das onze escolas que aderiram ao projeto, tendo atingido, em média, o número de projetos esperados a concurso (dois por agrupamento).

Foram também recolhidas evidências da efetiva utilização da robótica educativa nas escolas, quer pelos registos submetidos no fórum da comunidade, quer nos vídeos apresentados a concurso.

A disponibilização de material por parte do projeto permitiu que todas as escolas tivessem tecnologia disponível para participarem no mesmo. A formação inicial possibilitou que os professores e educadores (i) tomassem um primeiro contacto com os robôs (ii) se conhecessem e conhecessem os formadores. A comunidade de partilha online complementou a formação, criando um espaço de troca de experiências e esclarecimento de dúvidas, que contribuiu para o sucesso do projeto.

Verificamos que, dos oitenta e um professores inicialmente envolvidos na formação, quarenta e nove inscreveram-se na comunidade *Moodle* e trinta e um enviaram projetos a concurso, o que nos parece significativo, sobretudo pela qualidade e criatividade dos trabalhos submetidos a um concurso com júri internacional.

O desenho do projeto, assentando na formação de professores, participação em comunidade e tendo por objetivo a participação num concurso, revelou-se adequada à promoção da utilização da robótica educativa nestes níveis de ensino [1]. Assim, perspetivamos a continuidade deste projeto, no próximo ano letivo, abrindo-o a novos agrupamentos.

Pensamos que será interessante, no futuro, revisitar esta comunidade, tentando perceber se continuam a usar a robótica educativa e em que contextos.

REFERÊNCIAS

[1] Rodrigues, M. R., & Felício, P. (2019). The use of ground robots in primary education: Students' perspectives. Em International Symposium on Computers in Education (pp. 107–111). Instituto Politécnico de Tomar.*)*

[2] Pereira Marques, J. J., & Ramos, V. (2017). Robótica educativa em Portugal – estado da arte. Revista de Estudios e Investigación en Psicología y Educación, 193–197

[3] Pedro, A., Matos, J. F., Piedade, J., & Dorotea, N. (2017). Probótica Programação e robótica no Ensino Básico - Linhas Orientadoras. Instituto de Educação da Universidade de Lisboa.

[4] Coelho, A., Almeida, C., Almeida, C., Ledesma, F., Botelho, L., & Abrantes, P. (2016). Iniciação à Programação no 1º.Ciclo do Ensino Básico | Linhas Orientadoras para a Robótica. Direção-Geral da Educação.

[5] Ramos, V. P. (2020). Robot Caramelo – Projeto de Robótica Educativa e Inclusão. Medi@ções, Vol. 8 N.o 2, 33-46 Páginas.

[6] Tadeu, P., Brigas, C., Pereira, A., & Arziev, A. (2020). A multidisciplinary project with Lego robot in a portuguese primary school. In F. J. H. Lucena, J. M. T. Torres, J. M. S. Reche, & S. A. García (Orgs.), Innovación docente e investigación educativa en la sociedad del conocimiento (pp.107-119). Dykinson.

[7] Heikkilä, M., & Mannila, L. (2018). Debugging in Programming as a Multimodal Practice in Early Childhood Education Settings. Multimodal Technologies and Interaction, 2(3), 42.

[8] Desidério, R. C. S., & Do Prado, P. S. T. (2023). A robótica como alternativa para o ensino e aprendizagem da Matemática na educação infantil: Revisão sistemática da literatura. CONTRIBUCIONES A LAS CIENCIAS SOCIALES, 16(4), 1627–1641.

[9] E. Wenger, Communities of Practice: Learning, Meaning, and Identity, vol. 9. Cambridge University Press, 1998. doi: 10.2277/0521663636.

[10] C. P. Coutinho, Metodologia de Investigação em Ciências Sociais e Humanas: Teoria e Prática, 2.ª edição. Coimbra: Almedina, 2013.

[11] J. Amado, *Manual de Investigação Qualitativa em Educação 3ª edição*. Coimbra: Imprensa da Universidade de Coimbra / Coimbra University Press, 2017.

[12] Christensen, L. B., & Turner, L. A. (2020). Research Methods, Design, and Analysis. Pearson.

[13] Yin, R. (2018). Case Study Research: Design and Methods (2nd Edition). SAGE Publications.

[14] Meirinhos, M., & Osório, A. (2010). O estudo de caso como estratégia de investigação em educação. EduSer, 2(2), Artigo 2.

[15] Moreira, A., Sá, P., & Costa, A. P. (Eds.). (2021). Reflexões em torno de Metodologias de Investigação—Métodos (Vol. 1). Universidade de Aveiro.

Project-Based Learning in the curricular unit ICT in Professional Contexts – perceptions of Sociocultural Animation students

Sílvia Roda Couvaneiro
Departamento de Ciências e Tecnologias
Escola Superior de Educação do Instituto Politécnico de Setúbal
Setúbal, Portugal
silvia.couvaneiro@ese.ips.pt

João Grácio
Departamento de Ciências e Tecnologias
Escola Superior de Educação do Instituto Politécnico de Setúbal
Setúbal, Portugal
joao.gracio@ese.ips.pt

Ana Rute Martins
Departamento de Ciências e Tecnologias
Escola Superior de Educação do Instituto Politécnico de Setúbal
Setúbal, Portugal
ana.rute.martins@ese.ips.pt

Abstract – **This article reflects on the teaching of Information and Communication Technologies in Professional Contexts with Sociocultural Animation students. This curricular unit (CU) aimed to develop digital citizenship and stimulate students' personal and professional growth through active and project-based learning strategies. The objectives included analysing software, integrating technology into the profession, planning interventions, using software and online tools, creating multimedia presentations, organizing digital portfolios, and understanding distance learning platforms. The CU was lectured by three professors and the study presented in this article involved 26 students that were enrolled in the 2nd semester of 2022/2023. Student-centred teaching strategies, such as Project-Based Learning, were adopted to prioritize learning and hands-on, real-world experiences of project planning and management. The activities focused on situated learning and service to the community, allowing students to implement their projects with target audiences identified by them. The results of a questionnaire applied at the end of the semester indicated positive perceptions in relation to the three areas in which it focused, and which relate to learning, motivation, and performance. In conclusion, the project-based learning strategy in higher education has been shown to have a favourable impact on students' digital skills and others that are transferable to their professions, including project management, communication, collaboration, autonomy, and self-regulation. The study suggests the potential benefits of project-based learning can be applicable to other areas and recommends expanding research to explore this approach more comprehensively.**

Keywords— Project-Based Learning, Higher Education, Information and Communication Technologies, Digital Citizenship

I. Introduction

This article reflects on the teaching of the Curricular Unit (CU) of Information and Communication Technologies in Professional Contexts (ICTPC), which took place in the second semester of 2022/2023.

This CU is an integral part of the curricular offer of the Degree in Sociocultural Animation, having 70 hours of contact and 5 ECTS, and it is developed in the second semester of the first year of this course. In the academic year under study, 44 students were enrolled, and the CU was lectured by the three professors, who are the authors of this article.

The main objectives of the CU are the following: i) analysing and evaluating software, namely 'free' programmes available on the Web; ii) managing the use of technologies, integrating them naturally in the context of the profession; iii) planning actions/interventions, integrating ICT; iv) using the general purpose software in the context of the profession (real or simulated); v) using Web 2.0 tools to support publication and communication, to disseminate ideas and materials related to the work context; vi) designing, adjusting and using multimedia presentations; vii) organizing digital portfolios and viii) understanding how distance learning platforms work.

Centring teaching processes on students' learning in higher education, when preparing future professionals, means bringing learning to the top of priorities, even ahead of content [1]. As a way of centring teaching on students, as described in a publication on pedagogical innovation by the Portuguese Agency for the Assessment and Accreditation of Higher Education [2], in this study active learning strategies were considered relevant and were adopted, more specifically methods centred on inquiry and cooperation, as is the case of Project-Based Learning. The activities described in this article are also in line with what was proposed by Almeida, Gonçalves, Ó, Rebola, Soares and Vieira [2] regarding situated learning and community service, since students were able to implement their projects with the target audiences identified by their groups.

The activities developed were part of a strategy aimed at promoting digital citizenship in the context of higher education, through the design, implementation, and evaluation of sociocultural animation activities by students. Thus, its main objectives were to develop responsible digital citizenship, as well as to enhance students' personal and professional growth through the benefits of active, experiential, and project-based learning, while simultaneously working on their own digital skills.

Such activities were intended at developing students' digital competence, in their various areas: Information and data literacy; Communication and Collaboration; Digital content creation; Safety; and Problem Solving [3], simultaneously developing specific skills that were transferable to students' professional contexts, such as project management, communication and collaboration.

Hence, this article seeks to present evidence on the achievement of the CU objectives, analysing the students' perceptions in response to a questionnaire applied at the end of the semester. A theoretical context will be presented, followed by the description of the activities, the methodology adopted for the research, as well as the analysis of the data obtained and the presentation of the respective results.

Finally, some conclusions will be presented, believing this article can be useful, not only in the adaptation of methodologies and procedures in this CU context, of this specific area, but also in the context of other scientific areas and other CU.

II. Theoretical Framework

Learning has been much discussed over time and it is certainly one of the major concerns of all teachers and professors, that is, what is in fact the best model, method or technique that leads to significant learning by students?

On this matter, there are different learning theories and models. These are not necessarily contrary to each other, but rather complementary, since they represent what human learning is. Thus, perhaps they can be seen as complementary approaches which, besides valuable, are necessary [4]. Whether through response to stimuli (behaviourism), duplication of knowledge, based on base knowledge (cognitivism), through socialization (constructivism) or through the knowledge networks created (connectivism), an understanding and reflection on each one is fundamental, to understand how the work done with students can be improved [5].

Authors such as Bacich and Moran [6] state that several studies have found that, despite the importance of learning through transmission, there is a broader and deeper understanding when learning occurs through questioning or experimentation, the so-called active and meaningful learning, being valid for all levels of education, from very young children to higher education.

The specific context of higher education has increasing challenges that may impact the learning processes, such as an increase in the number of students, with different characteristics, and the necessary preparation for their future professional context, with growing specific and transversal needs, with particular high demands from the labour market [2].

In what innovative pedagogical strategies are concerned, authors such as Weimer [1] and Almeida, Gonçalves, Ó, Rebola, Soares and Vieira [2] point to methodologies that are distanced from the traditional paradigm of exclusive lecturing, suggesting teaching strategies that are centred on student learning and skills development. Several methodologies are suggested, such as: traditional methods adjusted to current times; methods centred on inquiry and cooperation, (as is the case of project-based learning - PBL); situated learning and community service (such as intervention projects); active strategies in pedagogical practices in the classroom (such as collaborative learning); and also the relocation of learning (taking advantage of the possibilities of virtual environments) [2].

PBL and community service methodologies have been implemented in the context of higher education, adapting to different disciplinary areas and with favourable results for learning and the development of transversal skills, also within the scope of digital citizenship as suggested by Pais, Dias and Benício [7], Prasetiyo, Sumardjoko, Muhibbin, Mahadir Naidu and Muthali'in [8] and Ngereja, Hussein and Andersen [9].

PBL is identified as a use of authentic and realistic projects, based on highly motivating and engaging questions, tasks or problems, to teach academic content to students in the context of cooperative work for problem solving [10], adapting to and being adequate to the specific context of higher education.

A similar idea is defended by Rodrigues [11], when the author refers that project work and the use of active learning methodologies promote the development of competences and enhance transversality, in relation to curricular areas.

Although there is no precise definition of PBL, Morgan [12] refers to this strategy as an activity that leads students to understand certain topics or subjects through their involvement in situations, whether real or simulated, in which they assume responsibility for their learning activities. Being a strategy that encourages students' autonomy and self-regulation, professors can take on the role of a guide or facilitator of the learning process [1] [2], which can lead to student involvement in tasks that are closer to real-world experiences [9].

Increasingly, such strategies have been being proved to take advantage of the potential of integrating technologies in the teaching, assessment, and learning processes, as these can enhance better learning and facilitate time and process management, namely through formative feedback [11]. This idea is also in line with the works of Ferreira, Nascimento, Santo and Guedes [13], as it is referred that there is currently a need to redesign teaching strategies, mediated by a digital culture, with active pedagogical methodologies, in which the student is encouraged to do, to think and problematize, through the creation of different flexible digital spaces that promote collaboration and learning.

The implemented activities that are described in this article, sought to rethink educational practices, recognizing the potential of digital environments for the construction of knowledge, as well as the potential of project-based learning. Thus, this study was based on an approach that will meet student-centred teaching and curricular and pedagogical innovation [1][2], particularly as it is oriented towards project-based learning, situated learning and service to the community, playing technology an important role in teaching and learning [2].

III. Methodoly

In this section, the activities carried out in class are described, along with the research methodology adopted for the study, which includes the research design, the procedures used to collect data and the data analysis strategy used.

A. Activities in class

In the ICTPC CU students began the semester by researching topics related to the use of the internet and digital citizenship, creating digital products, that were evidence of the learning developed. These were later gathered in an individual digital portfolio.

After exploring the initial topics, students were invited to select a theme within digital citizenship and to plan sociocultural animation activities to raise its awareness within a target audience of their choice, being the goals of such activities linked to project management, creating an authentic learning opportunity, in collaboration and with the integration of technologies in these processes. Students were expected to get in touch with everything that is behind the process of planning, managing, and implementing a project and how they could take advantage of digital tools to support them in each phase of these processes.

Collaboratively, each group edited a web page initiated by the three professors and which brought together all the ten themes and activities to be developed by each group. Throughout the semester, students planned their projects, collected, and analysed data that allowed them to fine-tune priorities regarding their themes, created presentation and dissemination materials for the activities, as well as the materials necessary for their implementation.

In the activities carried out by the students, the ten groups addressed topics such as cyberbullying, catfishing, fake news, safe use of the internet, as well as healthy management of technology use time. The activities were mostly implemented on campus, with four groups opting to carry out activities with school-age children.

At the end of the semester, the students put their activities into practice and collected data from the participants regarding their execution of the proposed activities. These data were later processed and analysed, and the students prepared them to be presented in class, together with all the activities and materials developed.

On the last day of classes, each group presented the result of the activities, and afterwards each one delivered an individual critical reflection on the learning developed throughout the semester along with the respective individual digital portfolio, which also brought together the materials executed in the group. Each student carried out their self-assessment regarding each of these elements, using a rubric, i.e., a grid of criteria and performance levels.

B. Research design and data collection

This study does not intend to generalize the results obtained, but rather to find evidence regarding the learning carried out throughout the activities developed with the students, looking for evidence on its relationship with the implemented strategies. Thus, it was considered relevant to adopt an eminently quantitative perspective [14], since the aim is to analyse an observable fact or phenomenon and measure/evaluate behavioural and/or socio-affective variables, which can be measured, compared and/or related [15], that is, a punctual situation, with well-defined characteristics and within the context of real life [16]. According to the same author [16], the case study is widely used when one intends to know the "how" and "why" of a certain phenomenon. For Ponte [17] the case study is an investigation that focuses on a particular situation, seeking to discover what is essential and characteristic in it and, in this way, contribute to the global understanding of a certain phenomenon of interest.

In this case, the data under analysis were collected through a questionnaire survey, carried out using the Google Forms tool, and it was used to collect data to understand a possible impact of the chosen PBL strategy, and the work carried out in three distinct areas: a) Learning, b) Motivation and c) Performance, based on an original instrument by Ngereja, Hussein and Andersen [9], which was adapted to the mother tongue of these students (European Portuguese) by two English teachers. Although the translated version of the instrument was not tested and validated with a different representative sample prior to the data collection, which represents a limitation of this study, we assume this as an exploratory study and intend to further develop it in the future, addressing its current limitations.

Nevertheless, the questionnaire was originally applied with the objective of analysing a similar situation, in which students experienced PBL in the context of higher education [9], which led the authors of the present article to choose this same instrument.

According to Oliveira, Vieira and Amaral [18], the questionnaire survey is a data collection instrument that allows quantifying, rigorously and objectively, that is statistically, the phenomenon under study. The authors of the original instrument that was adapted for this study [9], justify the need to measure student performance to improve the teaching processes, considering that learning itself is an abstract concept and therefore lacks the identification of indicators [9]. These authors justify the choice of the three areas (learning, motivation, and performance) because these are closely connected with student learning and that their perceptions of such constructs are significantly relevant to demonstrate the effectiveness of learning [9].

The questionnaire that was applied was divided into four parts, the first being related to the authorization to use data in research and the other three with the three areas under analysis. The first area contained four questions and the second and third areas both contained three questions, in a total of 10. In these questions, students had to read statements and evaluate or estimate their opinion, their level of agreement, using a Likert scale [15]. The three areas and the respective statements presented to the students concern the perception that they recognize regarding a possible impact of PBL on: 1) learning related to project management; 2) motivation regarding the activities; and 3) students' performance in future projects.

Like on the original instrument, data regarding age, gender and ethnicity were not collected since the authors of the present article also concur that this was irrelevant for the case under analysis [9]. Respondents had to indicate their degree of agreement with each of the statements on a scale of 1 to 5, corresponding to: 1 - "totally disagree", 2 - "disagree", 3 - "neither agree nor disagree", 4 - "agree" and 5 - "totally agree".

IV. Results Presentation and Analysis

In total, 26 responses were obtained, which is equivalent to 59% of the enrolled students, but to 74% of the students who attended the CU classes. The data relating to the statements of the three areas of the applied questionnaire are presented below.

As for the first area under analysis, Area A – Learning, students were asked about the impact that the work carried out had had on their learning in terms of project management.

Faced with the four statements, that included A1 - "The work carried out helped me to understand, in depth, various concepts related to project management.", A2 - "The work carried out gave me the opportunity to better relate to the concepts of project management projects.", A3 - "The work helped me to understand the different tasks inherent in project management, relating three fundamental components (technology, organization and innovation)." and A4 - "The work carried out provided me with an authentic project management experience.", it can be observed in the data presented in Table 1 that all respondents replied that they agree (4) or completely agree (5) with the statements (A1, A2, A3 and A4 - 100%), with no response to levels 1, 2 and 3.

TABLE I. AREA A – LEARNING

Area A statements	Number of Answers by Level				
	1	*2*	*3*	*4*	*5*
A1	0	0	0	7	19
A2	0	0	0	3	23
A3	0	0	0	9	17
A4	0	0	0	10	16

In the second area under analysis, Area B – Motivation, students were asked about the impact that the work carried out had had on their motivation.

Thus, regarding statements B1 - "Knowing that the project represented 30% of the final grade of the CU motivated me to put in extra effort.", B2 - "Knowing that the results of my project would be used as a support for learning the subject motivated me to put in extra effort." and B3 - "Working with my colleagues, in a group, was an additional motivating factor." it appears that there is greater dispersion in terms of the answers given than in relation to area A, as can be seen in table 2.

This happens mainly regarding statement B1, since not all students consider that the fact that this work is worth 30% of the final grade was an additional motivation factor. However, in the three statements, the vast majority considered that they agree (4) or completely agree (5) with statements B1 (84.6%), B2 (92%) and B3 (92%).

TABLE II. AREA B - MOTIVATION

Area B statements	Number of Answers by Level				
	1	*2*	*3*	*4*	*5*
B1	1	1	2	13	9
B2	0	0	2	9	15
B3	0	0	2	9	15

Regarding the third area under analysis, Area C – Performance, students were asked about the impact of the work carried out on their future performance.

When confronted with the statements C1 - "I will be able to better manage my projects in the future because of the experiences I gained from working on the project.", C2 - "I believe the product my group developed will be an excellent learning aid in future project management." and C3 - "I evaluate my team efforts as outstanding (i.e. collaboration, communication and sharing of knowledge within the team).", students' responses are mostly at the levels "agree" (4) or "totally agree" (5) with statements C1 (100%), C2 (92%) and C3 (96%) as presented in the data in Table 3. There are, however, 2 students who neither agree nor disagree that the work done is an excellent aid for future projects and one student who disagrees that the group's work was outstanding.

TABLE III. AREA C – PERFORMANCE

Area C statements	Number of Answers by Level				
	1	*2*	*3*	*4*	*5*
C1	0	0	0	10	16
C2	0	0	2	5	19
C3	0	1	0	9	16

The results presented here indicate that the students mostly perceived a favourable impact in relation to the three areas. The area in which most students agreed or strongly agreed that there was a favourable impact was area A – Learning, in which 100% of students agree (4) or strongly agree (5) with all statements. Most students totally agree (5) almost always with the statements in the three areas, except for statement B1 in which the majority (13 responses, 50%) responded that they agree (4) and then strongly agree (5) (9 responses, 34.6%).

The statement with which most students strongly agree (5) was A2 (23 responses, 88.5%), followed by the statements A1 and C2 as in both there were 19 students (73%) who completely agreed (5). These results seem to suggest that students recognize that the fact that they experienced the planning and implementation of a project allowed them to know the concepts of project management and that this will be important for them in their professional future.

V. CONCLUSIONS

The main goal of this study was to investigate students' perceptions regarding the areas of learning, motivation and performance when participating in activities that can be considered authentic learning opportunities, close to real-world experiences [9] in the implementation of sociocultural animation activities within the scope of digital citizenship, which was actually the main topic of the Curricular Unit ICT in Professional Contexts.

This study contains limitations that do not allow the conclusions to be generalizable, mainly regarding the collection of data that was based solely on the application of a questionnaire, that was not previously tested and validated, but allowed collecting quantitative data on the perceptions of the students. A broader study is suggested, even considering qualitative data, namely through interviews in focus groups, which may bring other data that may allow exploring these in more depth, along with the triangulation of results. Contrasting these results with other data collections related to the assessment that students make of the quality of teaching may also bring relevant conclusions.

Nevertheless, the results presented here, even though they are not generalizable, seem to point to a favourable impact of PBL in the context of higher education. This is in line with the results of the study presented by Ngereja, Hussein and Andersen [9]. Furthermore, despite not being comparable realities, the results presented here show even higher percentages of agreement than in that study (mainly the perception of the impact in area A – Learning, which was 100%, but globally in the three areas).

Hence, it is considered that PBL could be a strategy that, besides allowing teaching to be centred on student learning [1][2], will also enable both the development of specific skills in the subject area in question, in this case the digital ones, and simultaneously the development of transversal skills that will concern project management, such as communication and collaboration, teamwork and co-creation, for example, as well as autonomy and self-regulation, being areas of competence identified as fundamental to be developed in the context of higher education [1] [2].

Moreover, despite the specificity of the activities described here, this experience may be valid in the context of other scientific areas, allowing this strategy to be adapted to a variety of curricular units, which is also in line with the work of other authors [7][8][9].

References

[1] M. Weimer, "Learner Centered Teaching: Five Key Changes to Practice," Jossey-Bass, 2002.

[2] L. Almeida, S. Gonçalves, J. Ó, F. Rebola, S. Soares e F. Vieira, "Inovação Pedagógica no Ensino Superior - Cenários e Caminhos de Transformação. A3ES READINGS, 16. Agência de Avaliação e Acreditação do Ensino Superior, 2022.

[3] M. Lucas, A. Moreira e A. R. Trindade, "DigComp 2.2: Quadro europeu de competência digital para cidadãos com exemplos de conhecimentos, capacidades e atitudes", UA Editora, 2022. https://doi.org/10.48528/4w7y-j586

[4] J. Greeno, "The Situativity of Knowing, Learning, and Research, American Psychologist," vol. 53, pp. 5-26, 1998. http://dx.doi.org/10.1037/0003-066x.53.1.5

[5] G. Siemens, "Connectivism: Learning Theory or Pastime of the Self-Amused?" 2006.

[6] L. Bacich e J. Moran, "Metodologias ativas para uma educação inovadora: Uma abordagem teórico-prática," Editora Penso, 2018.

[7] S. C. Pais, T. S. Dias, D. Benício, "Connecting Higher Education to the Labour Market: The Experience of Service Learning in a Portuguese University," Educ. Sci., vol. 12, p. 259, 2022.

[8] W. H. Prasetiyo, B. Sumardjoko, A. Muhibbin, N. B. Mahadir Naidu e A. Muthali'in, "Promoting digital citizenship among student-teachers: The role of project-based learning in improving appropriate online behaviors, Participatory Educational Research, vol. 10(1), pp. 389-407, 2023.

[9] B. Ngereja, B. Hussein e B. Andersen, "Does Project-Based Learning (PBL) promote student learning? - A performance evaluation," Educ. Sci., vol. 10, p. 330, 2020.

[10] W. N. Bender, "Aprendizagem baseada em projetos - educação diferenciada para o século XXI," Editora Penso, 2014.

[11] A. L. Rodrigues, "A metodologia de trabalho de projeto com integração de tecnologias digitais no ensino superior," Humanidades & Inovação, vol. 8(50), pp. 364–376, 2021.

[12] A. Morgan, "Theoretical aspects of project-based learning in higher education," British Journal of Educational Technology, vol. 14(1), pp. 66–78, 1983.

[13] M. S. B. Ferreira, M. B. D. C. Nascimento, M. I. M. Santos e J. T. Guedes, "Aprendizagem com Tecnologias: Sinergia de saberes e mídias digitais," Contribuciones a Las Ciencias Sociales, vol. 16(6), pp. 3994–4004, 2023.

[14] J. W. Creswell, "Projeto de pesquisa: Métodos qualitativo, quantitativo e misto," Artmed, 2010.

[15] C. Coutinho, "Metodologia de Investigação em Ciências Sociais e Humanas: teoria e prática," Edições Almedina, 2011.

[16] R. K. Yin, "Estudo de Caso - Planejamento e Métodos," Bookman, 2005.

[17] J. P. Ponte, "Estudos de caso em educação matemática," Bolema, vol. 25, pp. 105-132, 2006.

[18] A. L. de Oliveira, C. C. Vieira e M. A. Amaral, "O questionário online na investigação em educação: Reflexões epistemológicas, metodológicas e éticas," pp. 39–67, 2021.

SCHOOL DROPOUT IN THE FEDERAL NETWORK EDUCATION OF BRAZIL: IS IT AN INHERENT INDIVIDUAL ATTRIBUTE OR IT LIES ON SETTING CONDITIONS?

Jabson Cavalcante Dias
Doctoral Students – Federal University of Tocantins. Quadra 109 Norte, 77001-090 Palmas, TO, Brazil.
jabson.dias@ifb.edu.br or 0000-0003-4723-5432

Tadeu Lucena da Silva
Doctoral Students – Federal University of Tocantins. Quadra 109 Norte, 77001-090 Palmas, TO, Brazil.
lucena.analista@gmail.com or 0000-0002-0902-4346

Marco Antônio Juliatto
Doctoral Students – Federal University of Tocantins. Quadra 109 Norte, 77001-090 Palmas, TO, Brazil.
juliatto@juliatto.eng.br or 0000-0002-5528-4069

Adriano Nascimento da Paixão
Statistic Department, Federal University of Paraíba. Paraíba, PB, Brazil.
anpaixao@gmail.com or 0000-0002-2717-3716

David Nadler Prata
Institute of Regional Development, Graduate Program of Computational Modeling, Federal University of Tocantins. Quadra 109 Norte, 77001-090 Palmas, TO, Brazil
ddnprata@gmail.com or 0000-0002-1414-4000

Abstract*—Studies shown that school dropout among young people in Brazil corresponds to 3% of the annual GDP and is equivalent to all state and municipal spending on basic education per year. The expectation is that, each year, the country has approximately 575,000 young people without basic education due to school dropout. Many aspects can lead to greater or lesser school dropouts. An important issue that can help to understand this school phenomenon is to disentangle which attributes are inherent to the individual and which are attributed to the setting, so that public policies could be developed in favor of reducing schools' dropouts. In this work, logistic regression methods were applied to the 2019 Nilo Peçanha Platform databases (approximately 250 thousand records). Results shown that demographic, geographic, economic, and school setting variables can be measured to understand their impacts in projecting schools' dropouts, enabling the elaboration and carrying out of preventive and corrective actions in schools.

***Keywords*—Brazilian School Dropout, Professional and Technological Education, Logistic Regression.**

I. INTRODUCTION

School dropout in professional and technological training is not a phenomenon exclusive to Brazil. It is a subject that all countries are concerned about and seek to understand the aspects involved in order to develop public policies and strategies for their mitigation [1], [2], [3], and ultimately reducing its impact on the economy [4].

In [5], authors categorized 68 levels at 70 publications, in which 666 possible causes of abandonment were classified. The majority of these studies focused on analyzing the individual's behavior as their reasons for abandonment. On the other hand, there were few studies that sought to evaluate the influence of the surrounding environment conditions on evasion.

Brazil has the National Information System for Professional and Technological Education (Sistec) [6] which aims to serve as a mechanism for recording and disseminating data on professional and technological education and to validate diplomas from Level 1 Technical Professional Education courses.

Due to problems in validating information for census and statistical purposes, the Nilo Peçanha Platform (PNP) was developed in the Federal Network of Professional, Scientific and Technological Education [7], [8], [9].

This work explores a research gap pointed out by [5] which stands for: Further studies for each professional field and across different professional fields would be desirable to include a broad scope of dropout variables as they would allow for aggregate estimates of effect sizes for each variable.

With the main objective of using variables that have supposed been little studied, this article should present a degree of novelty by establishing as goals the identification, through logistic regression, of the variables that contribute to evasion in technical courses.

This article is divided into 6 sections, including the introduction in the first section. The second section presents dropout rates in professional courses, a worldwide phenomenon. The third section describes the research databases: Sistec, PNP and the statistical model used in the research: Logit Model. The fourth section presents the work methodology. The fifth section shows the results and discussions of this article, closing with conclusions in the sixth section.

II. STATE OF THE ART

A. Dropout from professional courses

Dropout in Professional and Technological Education (EPT) is considered a serious problem worldwide. This is what international studies have been pointing out. An assessment of recent literature on the factors that affect completion of EPT training reveals that there is general agreement about the types of factors that can influence completion, but there is some disagreement about the specific factors identified [10].

Studies already carried out on evasion have partially agreement on the reasons that lead to scholar evasion [11],

[4]. Those who do not complete vocational training blame low social support for leaving their studies [12].

Results from a study in Hungary highlight the significant effects of school and family as reasons for school dropout, including previous school experiences, influence on place of residence, and labor market situation [3].

The labor market situation in different regions is another possible factor impacting educational decisions. In Canada, for example, older age contributes to increased dropout rates, just as lower wages and higher unemployment rates reduce the likelihood of school dropout. In Switzerland there is greater evasion in areas where there are many job opportunities for unskilled workers. However, in Italy, no effect of regional youth unemployment rates on school dropout behavior is found [13].

Due to the decrease in young people with professional training, over the next two decades, a considerable increase in the number of people receiving public benefits and a decrease in the active workforce is expected considering the aging of the population. Due to this lack of professionals, some governments are encouraging the population to remain in the job market beyond the minimum retirement age and are offering professional retraining initiatives to retain older generations [14].

Dropping out of the EPT poses risks to a country's growth, as the demand for professional qualifications is increasing. Also, the shutdown of professional learning programs can make difficult the opening of new placements in the market or new professional courses [13].

Public policy makers in developing countries consider technical secondary education as a key element in economic growth and poverty reduction. Unfortunately, there is evidence that technical secondary education programs in developing countries have high dropout rates [10].

Below is a consolidated list of the main studies and the main variables used to predict dropout rates in some countries:

TABLE I

Relevant studies and the main variables by countries

Author(s)	**Year**	**Country**	**Age**	**Gender**	**Ethnicity**	**Family income**	**Course shift**	**Teaching mode**	**Region**
Coneus_et_al	2008	Germany	No	Yes(F-)	No	-	-	-	Yes(West -)
Coneus_et_al	2011	Germany	Yes(-)	Yes(M+)	Yes(Mig+)	No	-	-	No
Greig	2019	Scotland	Yes(-)	Yes(M+)	Yes(Mig+)	-	-	-	Yes(Rural+)
Laporte_Mueller	2013	Canada	Yes(-)	No	Yes(White-)	-	Yes(Full_time)	No	Yes(Newfoundland and Labrador +)
Uhly	2015	Germany	-	Yes(F+)	-	-	-	No	Yes(Mecklenburg and Berlin +)
Coe	2014	Canada	Yes(+)	Yes(F-)	-	-	-	-	-
Karmel_Oliver	2011	Australia	Yes(+)	Yes(F-)	-	-	-	-	-
Kropp_et_al	2014	Germany	Yes(+)	No	No	-	-	-	-
Rohrbach-Schmidt Uhly	2015	Germany	Yes(+)	Yes(F-)	-	-	-	-	-
Yi_et_al	2015	China	No	Yes(M-)	No	No	-	-	No
Gambin_Hogarth	2016	England	Yes(+)	No	Yes(Min+)	-	-	-	-
Hjorth_et_al	2016	Denmark	Yes(-)	-	-	-	-	-	-
Mischler	2014	Germany	Yes(+)	No	No	-	-	-	-
Lestari_Setyadharma	2019	Indonesia	Yes(-)	Yes(F-)	Yes(NoWhite+)	-	-	-	-
Beicht_Walden	2013	Germany	-	Yes(F+)	Yes(Mig+)	-	-	-	No
Bessey_Backes-Gellner	2015	Germany	-	Yes(F-)	Yes(NonGerman +)	-	-	-	-

III. FRAMEWORKS

A. Sistec and PNP

The National Information System for Professional and Technological Education (Sistec)[11] and the Nilo Peçanha Platform (PNP) [12] are two databases that connect and belong to the Secretariat of Professional and Technological Education of the Ministry of Education of Brazil (Setec/MEC).

The data used for this study was extracted from the PNP, more specifically, data referring to the offers of high school technical courses in 2019.

[11] https://sistec.mec.gov.br/login/login

[12] https://www.gov.br/mec/pt-br/pnp

- Sistec

Sistec is a system for recording, disseminating data and validating diplomas for secondary-level courses in professional and technological education.

The system was established and implemented by the Ministry of Education (MEC) in 2009, through Resolution CNE/CEB nº 3/2009, through the Secretariat of Professional and Technological Education of the Ministry of Education [15].

Through Sistec, educational institutions offering professional and technological education enter information about secondary-level of technical and professional qualification courses, including enrollment, attendance, graduates, among other data.

Completing data in Sistec is one of the essential conditions to guarantee the national validity of the diplomas issued for technical courses [16].

Data feeding is mandatory for all teaching units accredited to offer Professional and Technological Education (EPT) courses, regardless of their administrative dependency (public or private), education system (federal, state and distrital) and the level of autonomy.

The information relating to the Federal Professional, Scientific and Technological Education (EPCT) Network for the year 2019 was exported and worked on in the PNP.

- Plataforma Nilo Peçanha (PNP)

Started in 2017, the Nilo Peçanha Platform (PNP) is intended for the collection, processing and publication of official data from the Federal Network for Professional, Scientific and Technological Education (Federal Network) [17].

The platform presents information about the units that comprise it, courses, teaching staff, students and technical-administrative staff, as well as financial data [17].

The PNP arises from the need to create a database convergent with the characteristics of professional and technological education, in which the necessary information is gathered to monitor the management indicators defined by Setec/MEC in conjunction with the control bodies.

Information relating to the year 2019 of enrollments in the Federal EPCT Network, referring to technical courses, was extracted from Sistec. After being normalized in the PNP, 480 thousand lines remained that represent registration information to this studied.

B. *Logistic Regression and related studies*

With the large amount of data currently available through institutional information systems, the use of logistic regression emerges as a powerful technique for predicting behavior in various areas of science. There are many studies providing examples of the application of logistic regression [18].

The logistic regression model has been increasingly used in different research. Currently, several studies have used logistic regression to identify and predict risk factors related to COVID-19, for example [19].

In the field of education, decades ago, several studies in different countries were carried out using logistic regression to predict students' academic performance [20], [21]. These studies have focused on the causes and characteristics of dropout in terms of prevention, building dropout prediction models, and the development of school dropout prevention systems [21].

The use of logistic regression (LR) in the field of school dropout has been widely used in educational studies. In the 1990s, [22], [23], [24], [25] used logistic regression models to study student persistence in colleges. In the 2000s, [26] and [27] developed studies on the use of logistic regression to capture the relationship between potential dropout factors and the result of student retention.

Recently, [28] used educational data to generate predictive models of student dropout using logistic regression. [29] carried out a study using machine learning techniques, including logistic regression, to predict academic performance. In the extensive systematic review carried out by [21], studies on dropout students and students at risk of dropping out from 2009 to 2021 were identified using various techniques, including logistic regression.

IV. METHODS

A. *Data Base*

This study used a secondary database produced by the Brazilian Ministry of Education – MEC, published by the Nilo Peçanha Platform, official data source of the Brazilian Federal Network of Professional, Scientific and Technological Education (RFEPCT). Data referring to the base year 2019, published in June 2020, was used. The database is open and can be accessed on the MEC[13] website.

Enrollment[14] data was used, which represents the set of data related to enrollments (enrollment, student, enrollment cycle, course, teaching unit, institution) from RFEPCT. The base has a record of 1,023,303 enrollments in 2019. For the study carried out, enrollment data from the type of courses equal to technical was used. With this filter for technical courses, a base with 480,273 enrollments was used. The reason for choosing only technical courses is based on the law that created the RFEPCT[15], in which technical training is a priority in the percentage of offer (at least 50%) and due to its minimum duration of 800 class hours, allowing for annual monitoring.

The data dictionary presented in the registration database of the Nilo Peçanha Platform allowed 10 variables to be chosen and explored in this article, seeking their correlations through the use of the Logit method. The variables defined for the study were: Category of Situation (Completes - In progress - Evaded), as dependent variable, and Color/Race, Age, Institution, Education Modality, Region of Brazil, Family Income, Sex, Type of Offer and Shift, like other correlation variables. Continuing with the filters, those for Color and Race that were not filled in during the registration process were removed. With this procedure, the registration base had 361,090 registrations. Then, records that did not presented information on students' per capita family income

[13] https://www.gov.br/mec/pt-br/pnp/edicoes-1/ano-2020
[14] http://dadosabertos.mec.gov.br/pnp/item/118-2019-microdados-matriculas
[15] https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2008/lei/l11892.htm

were removed, reducing enrollment to 249,959. Finally, enrollment records where the age record is empty or were under the age of 14 were removed, given that the entry into technical courses takes place at least with complete primary education, and in Brazil the minimum age for carrying out work as a young apprentice is 14 years, according to Law No. 10,097, of December 19, 2000[16], and the Consolidation of Labor Laws[17]. With this last filter, the database that was used to construct the correlations contained 249,893 enrollment records.

The next step was to transform the variables selected for the study into dummy variables. This transformation took place in the form shown in Table II.

TABLE II

Variables of technical courses – Nilo Peçanha Platform – 2019 Enrollment.

#	Variable	Data Categories	Assumed values
1	Student Enrollment Status Category	Finishers Ongoing Evaded	1 – Evaded 0 – Not evaded
2	Student's color/race	Yellow White Indigenous Brown Black	1 – White 0 – Other Color/Race
3	Student Age	Numeral	Integer
4	Course teaching modality	Distance education In-person Education	1 – Distance education 0 – In-person Education
5	Student's Family Income	0<RFP[a]<=0,5 0,5<RFP<=1,0 1,0<RFP<=1,5 1,5<RFP<=2,5 2,5<RFP<=3,5 RFP>3,5	499 [bc] 998 1497 2495 3493 3494
6	Gender of the student	Masculine Feminine	1 – Male 0 – Female
7	Course shift	Nocturnal Full Not applicable Morning Afternoon	1 – Night 0 – Other Shifts
8	Offer Type	Integrated into high school Concomitant to high school Subsequent high school Other combinations that are not integrated	1 – Integrated into high school 0 – Other types of offer
9	Metropolitan Region of the Institution	Metropolitan region Other regions (rural)	1 – Metropolitan region 0 – Other regions
10	Student's geographic region	Midwest North East North Southeast South	1 Midwest, 0 otherwise 1 Northeast, 0 otherwise 1 North, 0 otherwise 1 Southwest, 0 otherwise South, reference variable

[a.] RFP = Family Income per capita. Note. Authors' own elaboration.

[b.] Values referring to the Brazilian minimum wage in 2019. Year of the database used.

[c.] The Family Income field was adjusted to salary ranges based on the Brazilian current minimum wage in 2019 established the amount of R$ 998.00.

The descriptive analyzes of the database revealed the percentages of dropouts in each of the analyzed characteristics, as shown in table III.

TABLE III

Percentages of dropouts by variable - 2019 enrollment.

Variable	Percentage of students dropped out
Student's color/race	White (12.77%), Other races (14.77%)
Student age (average)	Evaded (24 years), Non-evaded (21 years)
Sex (Gender) of the student	Male (15.15%), Female (12.94%)
Student's Family Income (average)	Evaded (960 reais), Non-evaded (1061 reais)
Course teaching modality	In person (14.37%), remotely (8.09%)
Type of offer	Integrated (8.95%), Subsequent and concomitant (21.77%)
Course shift	Night (23.91%), Morning and Afternoon (10.95%)
Metropolitan Region of the Institution	Metropolitan (13.50%), Interior (14.52%)
Student's geographic region	Midwest (16.97%), Northeast (13.13%), North (16.13%), Southeast (11.58%) and South (18.76%)

B. Logistic regression - Logit Model

The logistic regression technique is a statistical tool used in predictive analysis. The interest in measuring the probability of an event occurring is extremely relevant in several areas, such as marketing, advertising, internet, fraud detection, medical assistance, in relation to financial and insurance risks or even studying the workforce [30].

In the literature, the first use of the logistic model is found by [31] and [30]. The logistic regression model gained recognition after the work of [32] who analyzed the risk of coronary disease in a large project known as the "Framingham heart study". This work is considered an initial milestone for studies involving logistic regression.

According to [30] logistic regression, in its traditional form, consists of a model that relates a set of p independent (explanatory) variables $X_1, X_2, \ldots, X_p$ to a dependent variable (response) Y that assumes only two possible states, 0 or 1. The logistic model allows direct estimation of the probability of an event occurring (Y=1):

[16] https://www.planalto.gov.br/ccivil_03/leis/l10097.htm

[17] https://www.planalto.gov.br/ccivil_03/decreto-lei/del5452.htm

$$P(Y=1)=\frac{\exp(\beta_0+\beta_1x_1+\cdots+\beta_px_p)}{1+\exp(\beta_0+\beta_1x_1+\cdots+\beta_px_p)}$$

And consequently,

$$P(Y=0)=1-P(Y=1)=\frac{1}{1+\exp(\beta_0+\beta_1x_1+\cdots+\beta_px_p)}$$

Where β_1 is the model parameters, estimated by the maximum likelihood method. The transformation behind the logistic model is the so-called Logit transformation, denoted by $g(x)$. It is a linear function in parameters β, continuous and can vary from $-\infty$ to $+\infty$:

$$logit(x)=g(x)=ln\left[\frac{P(Y=1)}{1-P(Y=1)}\right]=\beta_0+\beta_1x_1+\cdots+\beta_px_p$$

For [30] there are at least two reasons for using the logistic model in the analysis of dichotomous response variables: 1) from a mathematical point of view, it is extremely flexible and easy to use; 2) allows a very rich and direct interpretation of results.

J. A Anderson [33] emphasizes that logistic discrimination can be applied to a wide variety of families of distributions, as the Logit linearity assumption is valid in a large number of probability distribution functions, such as, for example, the multivariate normal distribution [34].

Logit regression predicts the probability of an occurrence of any event by fitting the data into a Logit function [35].

For the study in question, logistic regression with the application of the Logit model meets the objective of identifying variables that contribute to dropout rates in technical courses in the Federal Network of Professional, Scientific and Technological Education in Brazil.

Illustratively, Fig.1 represents the methodological flow followed to obtain and process the data and use logistic regression with the support of the free software Rstudio® for build the model and presentation of the results described in the following section.

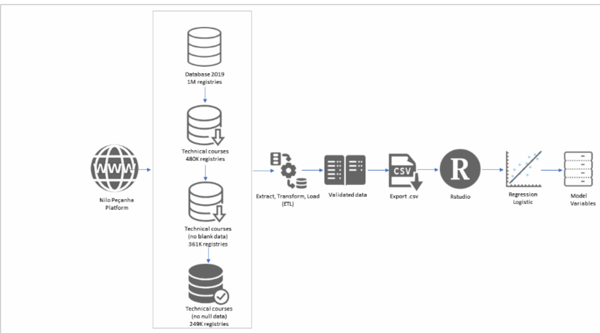


Fig. 1. Methodological flow.

V. RESULTS AND DISCUSSION

Based on the results of the logistic regression, we can verify which factors influence the student's decision to drop out, considering the correlation with the nine variables analyzed: sex, age, race/color, family income, teaching modality, course shift, type of offer, institution in metropolitan region and region of Brazil. Based on statistical tests, it is possible to see that the model has a reasonable discriminating capacity and was able to classify 64.14% of the analyzed population.

All nine variables were significant at the 5% level. Of the nine variables analyzed, seven are categorical and two are numerical, and among the numerical variables it is possible to evaluate the direction of the correlation.

The variables that represent individual characteristics: race/color, age and sex all showed a statistically significant effect. The student being white has a negative effect on the decision to drop out, therefore white students are 0.88 (CI 95% 0.85-0.90) less likely to drop out of technical courses than non-white students (black, brown, yellow and indigenous), Table IV.

The student's age has a positive effect on the decision to drop out, thus, the older the age, the greater the risk of the student deciding to drop out, according to the odds ratio, Table V. Students over 26 years old have 1.26 (CI 95% 1.21-1.31) more likely to drop out than students aged 26 or younger. This result in Brazil, is in line with the literature review carried out by [5] who reviewed 70 wide studies and identified 15 works that studied age as explanatory variable for evasion and most of these studies support this hypothesis. Among these works, [1], who studied dropout rates in Germany with panel data between 2000 and 2007 and noticed that students over the age of 19 have a greater risk of dropping out than students of younger age.

The fact that students are male has a positive effect on the decision to drop out, therefore male students are 1.15 (CI 95% 1.12-1.14) more chance to drop out of technical courses than female students in Brazil, Table IV. These results corroborate part of the work reviewed by [5] who carried out a bibliographical review on the factors that influence evasion and identified that approximately half of the studies found that women are less likely to evade. For example, [2] studied the risk factors associated with evasion in Scotland with data between 2007 and 2015 and identified that sex has an influence, with women having less risk of evading, when analyzing the entire country, which corroborates with the present research.

The variable associated with the economy, family income, has a negative effect on the decision to drop out, so the lower the student's family income, the greater the risk of dropping out [5]. [36] carried out a literature review on the factors that influence the evasion and the closest variable to this is the socioeconomic status, The authors found that lower socioeconomic status has a positive effect on the decision to drop out, so minority or majority students are more likely to drop out when they have a lower socioeconomic status, which corroborates the present study.

The financial composition is an external aspect of the motivation to evade. [37] investigated family-related factors that are associated with school dropout, including the composition of family income. The association between

family income and the reduction in the employability rate reduces access to education, increasing dropout rates as a result [38]. The economic difficulties faced by students and their families are a factor that impacts dropout rates in technical courses.

For [39] there is also evidence that the higher the parents' level of education and their economic conditions, the greater the chances of students completing their courses, as well as the lower the level of education. In addition, the fewer the financial resources the greater the chances of interrupting the study and give up [40]. In other study on evasion [41] authors reported difficulties in commuting or related to transportation, as well as social, cultural and economic vulnerability of the student as a result of changing cities or housing are motivators that permeate material issues directly related the economic and social condition of students.

In this Brazilian study, students of technical courses offered in the distance learning modality are less likely to drop out than students in the face-to-face teaching modality, which contradicts the works analyzed such as that of [42] and other works as described below. However, in this work it is worth highlighting that the percentage of distance learning is around 4.5% of the total sample. The teaching modality is an internal aspect of course organization [43]. Therefore, it is configured as an institutional factor [44]. The lack of time for students to complete the course is one of the main causes of dropout in this type of teaching. Combined with financial aspects and lack of adaptation to the modality [45]. Students' perceptions of distance learning courses may be negative if they experience distance between teachers and students, which may influence their decision to remain on the course [46]. For [47] self-efficacy in online technologies, readiness for online learning and previous online experience are important factors for predicting dropouts, these characteristics may explain the lower dropout rates among distance learning students in the federal education network of Brazil.

Technical courses offered as part of secondary education are the modality with the lowest dropout rate in the Federal Network of Brazil. The low dropout rates in this modality are related to the high levels of support for students [43]. It is noteworthy that in the case of the Federal EPCT Network, the very Law that created it, Law No. 11,892/2008[18], means that institutions must guarantee (prioritize) a minimum of 50% of vacancies to provide technical professional education to the secondary level, primarily in the form of integrated courses. For [48] in today's society, completing high school is a prerequisite for a minimum standard of living. Public school students consider, although fragile, having a diploma to be something that motivates them to study [49]. The fact that the integrated technical course offers the student the possibility of completing both high school and professional training is attractive to the public, which in this modality is made up of young people of regular school age, that is, from 14 to 17 years old.

Night school students are more likely to drop out than students in other technical course shifts. Night shift students have to complete a similar workload to day shift students. In many cases, the choice for a night shift was due to the need to work, which is understood as one of the main determinants of dropout from night courses as it leads to low learning performance. This occurs because night school students are tired from various activities carried out during the day [50]. For [51], the daily routine of night school has a unique characteristic, as it receives a physically exhausted student, as he usually arrives at school after a day of work.

The three variables related to the institution, distance learning course, course shift and type of offering also showed significance at the 5% level. The student following the course via distance learning has a negative effect on the decision to drop out, so students who study remotely have less risk of dropping out than students who study in person.

The two variables associated with geographic region, metropolitan region and macroregions, were analyzed in the model. Students living in metropolitan areas has a negative effect on the decision to drop out, so students who live in metropolitan areas have less risk of dropping out than students who live in the countryside. In the same way as the macro-regions of Brazil (Center-West, Northeast, North, Southeast and South), which have a negative effect on dropout rates, students from the Center-West, Northeast, North and Southeast regions have less risk of dropping out when compared with the other regions. Unfortunately, some dropout categories are too diverse for comparison purposes, which means that a detailed understanding of the specific studies is necessary to interpret the findings in relation to these demographic issues in the metropolitan region compared to the Brazilian regions, which is the case of the studies of [5].

In addition to the regression equations already discussed, this work also analyzed the Anova of the estimators, in which it was possible to measure the influence of each variable in the logistic model, Table IV.

TABLE IV

Logit Model Result.

Intercept)	**Coefficient**	**p-Value**
	-2.51E+00	<2e-16***
Student's race_color (white)	-1.31E-01	<2e-16***
Student age	1.82E-02	<2e-16***
Male)	1.40E-01	<2e-16***
Student's family income	-9.25E-05	<2e-16***
Teaching modality (distance)	1.02E+00	<2e-16***
Offer type (Integrated)	-7.64E-01	<2e-16***
Course shift (Night)	1.36E-01	<2e-16***
Metropolitan Region of the Institution	-1.81E-01	<2e-16***
Student geographic region		
\`Midwest\`	-7.79E-02	0.00183**
\`Northeast\`	-5.02E-01	<2e-16***
\`North\`	-2.53E-01	<2e-16***
\`Southeast\`	-5.32E-01	<2e-16***
\`South\`	NA[a] (reference variable)	NA (reference variable)

[a] NA - Not applicable.

[18] https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2008/lei/l11892.htm

TABLE V

Odds ratio of Logit Model

	Coefficient	p-Value
(Intercept)	0.081	<2e-16***
Student's race_color (white)	0.877	<2e-16***
Student age	1.266	<2e-16***
Male)	1.146	<2e-16***
Student's family income	0.809	<2e-16***
Teaching modality (distance)	2.677	<2e-16***
Offer type (Integrated)	0.440	<2e-16***
Course shift (Night)	1.183	<2e-16***
Metropolitan Region of the Institution	0.840	<2e-16***
Student geographic region		
\`Midwest\`	0.937	0.00183**
\`Northeast\`	0.607	<2e-16***
\`North\`	0.774	<2e-16***
\`Southeast\`	0.580	<2e-16***
\`South\`	NA[a] (reference variable)	NA (reference variable)

[a] NA - Not applicable.

The factor that most influences the model to identify students at risk of dropping out is the type of offer as indicated by the Analysis of Variance (ANOVA) on regression estimators. Thus, as previously explained, students with the integrated type of offer have less risk of dropping out, therefore, anti-evasion policies must mainly monitor students of other types of offers (concomitant and subsequent) to identify the reasons that may encourage them to drop out, such as family problems, excessive work and difficulty in getting involved with the class.

TABLE VI

Anova of the regression estimators

Intercept)	Overall
Race_color (white)	9.03
Age	21.50
Male)	11.17
Family income	13.57
Modality (distance)	26.18
Offer type (Integrated)	47.45
Night shift)	8.48
Metropolitan region	14.01
Regions	
\`Midwest\`	3.12
\`Northeast\`	24.04
\`North\`	10.29
\`Southeast\`	25.07
\`South\`	0.0 (reference variable)

The second most important variable is the modality, in which students on distance learning courses have less risk of dropping out than students on in-person courses. The third most important variable is the Southeast region, followed by the Northeast region and age.

The ROC curve demonstrates the ability reasonable of the regression model to identify students at risk of dropping out and students who do not drop out, through sensitivity and specificity, as shown in the figure below. This model achieved a sensitivity of 65.9% and a specificity of 59.8%.

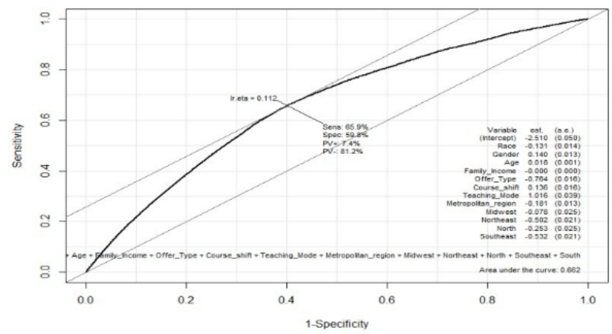


Fig. 2. ROC Curve.

Using Anova (Table VI) it is possible to identify the importance of the variables. To illustrate this importance, two variables with high importance were selected: Age and Offer type. In the sigmoid function, which predicts the risk of dropout based on these two variables, it is possible to observe that for older students and those who attend non-integrated courses (subsequent and concomitant) the risk of dropout is greater, Fig.3.

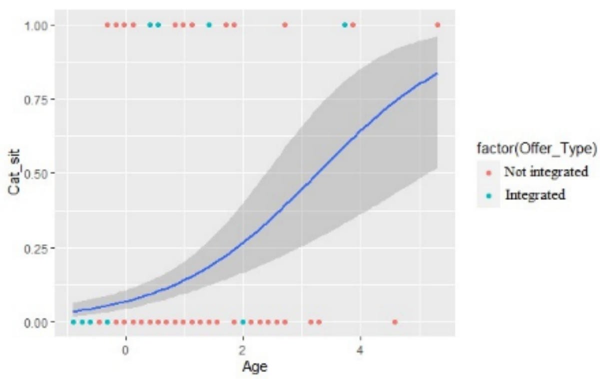


Fig. 3. Sigmoid Function of the Model.

VI. CONCLUSION

Among the demographic variables analyzed, we observed that older age and male gender increase the risk of dropping out, while the student being of white color/race decreases the risk of dropping out. The family income variable had an inverse effect on the risk of dropping out, therefore, students with lower family income have a higher risk of dropping out.

Regarding the institutional variables analyzed, we observed that students of technical courses in face-to-face teaching and night school students have a higher risk of dropping out, while technical students integrated into high school have a lower risk of dropping out compared to other types of offerings.

On the other hand, among the geographical variables analyzed, we observed that students who study in a teaching unit in a metropolitan region reduce the risk of dropping out compared to students who are from the countryside. And the student being from the Southeast, Northeast, North or Central-West region, in that order, has reduced the risk of dropping out.

Dropping out of technical courses is a social process that demands complex prevention and monitoring actions with the implementation of public policies that encourage retention in school.

The study carried out makes it possible for managers of the Federal EPCT Network to understand dropout rates in technical courses in Brazil and, therefore, mitigate the effects with policies and programs that can be developed to act on variables inherent to the academic environment and not only intrinsic to students. Especially in the case of evasion of distance learning and night learning.

It is important to highlight that these behaviors were perceived using data prior to the Covid-19 pandemic.

In this sense, future work needs to be developed with data collected during the pandemic and post-pandemic period to assess whether the scientific findings remain the same, as it may influence actions that may be developed from that period.

It is also recommended that this study be replicated in other types of offers in the Brazilian EPT with the same methodology to observe whether the correlations found remain the same. Applying the proposed methodology to specific courses or technological axes can bring relevant contributions to identifying the typical behaviors of certain variables regarding evasion.

The addition of new variables and techniques to the model proposed in the work by Cox [52] and even using machine learning can increase the accuracy of the model to improve the quality of the results obtained.

ACKNOWLEDGMENT

Special thanks to the financial support to FAPDF (Fundação de Apoio à Pesquisa do Distrito Federal), the academic support to the Universidade Federal do Tocantins and the professional support to the Instituto Federal de Educação, Ciência e Tecnologia de Brasília.

REFERENCES

[1] K. Coneus, J. Gernandt, and M. Saam, "Noncognitive Skills, School Achievements and Educational Dropout," *Schmollers Jahrb.*, vol. 131, no. 4, pp. 547–568, 2011, doi: 10.3790/schm.131.4.547.

[2] M. Greig, "Factors affecting Modern Apprenticeship completion in Scotland," *Int. J. Train. Dev.*, vol. 23, no. 1, pp. 27–50, 2019, doi: 10.1111/ijtd.12142.

[3] I. Csehné Papp, M. Héder-Rima, and K. Dajnoki, "Dropping out – Hungarian experiences at vocational training," *Acta Med. Sociol.*, vol. 12, no. 33, pp. 103–124, 2021, doi: 10.19055/ams.2021.11/30/7.

[4] S. Wild and L. Schulze Heuling, "How do the digital competences of students in vocational schools differ from those of students in cooperative higher education institutions in Germany?," *Empir. Res. Vocat. Educ. Train.*, vol. 12, no. 1, 2020, doi: 10.1186/s40461-020-00091-y.

[5] S. Böhn and V. Deutscher, "Dropout from initial vocational training – A meta-synthesis of reasons from the apprentice's point of view," *Educ. Res. Rev.*, vol. 35, no. September 2020, pp. 1–14, 2022, doi: 10.1016/j.edurev.2021.100414.

[6] Ministério da Educação. Brasil., "Sistec - Sistema Nacional de Informações da Educação Profissional e Tecnológica," *Online*, 2009. https://sistec.mec.gov.br/login/login (accessed Mar. 09, 2022).

[7] Ministério da Educação. Brasil., "Plataforma Nilo Peçanha - PNP," *Online*, 2019. https://www.gov.br/mec/pt-br/pnp (accessed Mar. 25, 2022).

[8] Ministério da Economia. Brasil., "Siape - Sistema Integrado de Administração de Pessoal," *Online*, 2022. https://www.siapenet.gov.br/Portal/Servico/Apresentacao.asp (accessed Mar. 09, 2022).

[9] Ministério da Fazenda. Brasil., "Siafi - Sistema Integrado de Administração Financeira," *Online*, 2022. https://siafi.tesouro.gov.br/senha/public/pages/security/login.jsf (accessed Mar. 09, 2022).

[10] H. Yi *et al.*, "Exploring the dropout rates and causes of dropout in upper-secondary technical and vocational education and training (TVET) schools in China," *Int. J. Educ. Dev.*, vol. 42, pp. 115–123, 2015, doi: 10.1016/j.ijedudev.2015.04.009.

[11] T. Dahal, K. Topping, and S. Levy, "Patriarchy, gender norms and female student dropout from high schools in Nepal," *Compare*, vol. 00, no. 00, pp. 1–19, 2021, doi: 10.1080/03057925.2021.1987191.

[12] M. Meeuwisse, S. E. Severiens, and M. P. Born, "Reasons for withdrawal from higher vocational education. A comparison of ethnic minority and majority non-completers," *Stud. High. Educ.*, vol. 35, no. 1, pp. 93–111, 2010, doi: 10.1080/03075070902906780.

[13] D. Bessey and U. Backes-Gellner, "Staying within or leaving the apprenticeship system? Revisions of educational choices in apprenticeship training," *Jahrb. Natl. Okon. Stat.*, vol. 235, no. 6, pp. 539–552, 2015, doi: 10.1515/jbnst-2015-0603.

[14] H. Smulders, A. Cox, and A. Westerhuis, "Vocational Education and Training in Europe: Netherlands," 2019.

[15] M. da; B. Educação., "RESOLUÇÃO Nº 3, DE 30 DE SETEMBRO DE 2009," 2009. http://portal.mec.gov.br/dmdocuments/rceb003_09.pdf (accessed Mar. 09, 2022).

[16] M. da; B. Educação., "RESOLUÇÃO CNE/CP Nº 1, DE 5 DE JANEIRO DE 2021," *Online*, 2021. https://www.in.gov.br/en/web/dou/-/resolucao-cne/cp-n-1-de-5-de-janeiro-de-2021-297767578 (accessed Mar. 09, 2022).

[17] M. da; B. Educação., "PNP - Plataforma Nilo Peçanha: Guia de referência metodológica," *Online*, 2020. http://plataformanilopecanha.mec.gov.br/ (accessed Mar. 09, 2022).

[18] V. L. Miguéis, A. Freitas, P. J. V. Garcia, and A. Silva, "Early segmentation of students according to their academic performance: A predictive modelling approach," *Decis. Support Syst.*, vol. 115, pp. 36–51, Nov. 2018, doi: 10.1016/j.dss.2018.09.001.

[19] S. Mehrolia, S. Alagarsamy, and V. M. Solaikutty, "Customers response to online food delivery services during COVID-19 outbreak using binary logistic regression," *Int. J. Consum. Stud.*, vol. 45, no. 3, pp. 396–408, 2021, doi: 10.1111/ijcs.12630.

[20] B. T. Zewude and K. M. Ashine, "Binary Logistic Regression Analysis in Assessment and Identifying Factors That Influence Students ' Academic Achievement : The Case of College of Natural and Computational," *J. Educ. Pract.*, vol. 7, no. 25, pp. 1–6, 2016, [Online]. Available: https://eric.ed.gov/?id=EJ1115855.

[21] B. Albreiki, N. Zaki, and H. Alashwal, "A systematic literature review of student' performance prediction using machine learning techniques," *Educ. Sci.*, vol. 11, no. 9, 2021, doi: 10.3390/educsci11090552.

[22] J. Levin, James; Wyckoff, "Student Characteristics That Predict Persistence and Success in Baccalaureate Engineering," *Inst. Educ. Sci. - ERIC*, vol. 4, pp. 1–23, 1990, [Online]. Available: https://eric.ed.gov/?id=ED320497.

[23] J. D. House, "The relationship between academic self-concept and school withdrawal," *J. Soc. Psychol.*, vol. 133, no. 1, pp. 125–127, 1993, doi: 10.1080/00224545.1993.9712129.

[24] M. Besterfield-Sacre, C. J. Atman, and L. J. Shuman, "Characteristics of freshman engineering students: Models for determining student attrition in engineering," *J. Eng. Educ.*, vol. 86, no. 2, pp. 139–149, 1997, doi: 10.1002/j.2168-9830.1997.tb00277.x.

[25] K. G. Schaefers, D. L. Epperson, and M. M. Nauta, "Women's Career Development: Can Theoretically Derived Variables Predict Persistence in Engineering Majors?," *J. Couns. Psychol.*, vol. 44, no. 2, pp. 173–183, 1997, doi: 10.1037/0022-0167.44.2.173.

[26] B. F. French, J. C. Immekus, and W. C. Oakes, "An examination of indicators of engineering students' success and persistence," *J. Eng. Educ.*, vol. 94, no. 4, pp. 419–425, 2005, doi: 10.1002/j.2168-9830.2005.tb00869.x.

[27] J. J. J. Lin, P. K. Imbrie, and K. J. Reid, "Student retention modelling: An evaluation of different methods and their impact on prediction results," *2009 Res. Eng. Educ. Symp. REES 2009*, pp. 1–6, 2009.

[28] J. H. Lee, M. Kim, D. Kim, and J. M. Gil, "Evaluation of Predictive Models for Early Identification of Dropout Students," *J. Inf. Process. Syst.*, vol. 17, no. 3, pp. 630–644, 2021, doi: 10.3745/JIPS.04.0218.

[29] N. N. Sanchez-Pozo, J. S. Mejia-Ordonez, D. C. Chamorro, D. Mayorca-Torres, and D. H. Peluffo-Ordonez, "Predicting High School Students' Academic Performance: A Comparative Study of Supervised Machine Learning Techniques," *Futur. Educ. Innov. Work. Ser. - Mach. Learn. Digit. Technol. Educ. Innov. Work. 2021*, pp. 1–6, 2021, doi: 10.1109/IEEECONF53024.2021.9733756.

[30] A. J. Scott, D. W. Hosmer, and S. Lemeshow, *Applied Logistic Regression.*, vol. 47, no. 4. 1991.

[31] D. R. Cox and S. E. J., *Analysis of Binary Data*. 1989.

[32] J. Truett, J. Cornfield, and W. Kannel, "a Multivariate Analysis of the Risk of," vol. 20, no. 2, pp. 511–524, 1967.

[33] J. A. Anderson, "7 Logistic discrimination," *Handb. Stat.*, vol. 2, pp. 169–191, 1982, doi: 10.1016/S0169-7161(82)02010-0.

[34] C. J. Peng, K. L. Lee, and G. M. Ingersoll, "An Introduction to Logistic Regression Analysis and Reporting; The Journal of Educational Research, Vol. 96(1)," *J. Educ. Res.*, vol. 96, no. September 2013, pp. 3–14, 2002.

[35] S. K. Singh, R. W. Taylor, M. M. Rahman, and B. Pradhan, "Developing robust arsenic awareness prediction models using machine learning algorithms," *J. Environ. Manage.*, vol. 211, pp. 125–137, 2018, doi: 10.1016/j.jenvman.2018.01.044.

[36] H. Fjørtoft, "Navigating the boundaries between home, work and school. Teaching values and literacies in VET," *Int. J. Educ. Res.*, vol. 85, no. July, pp. 157–166, 2017, doi: 10.1016/j.ijer.2017.07.012.

[37] R. W. Rumberger, R. Ghatak, G. Poulos, P. L. Ritter, and S. M. Dornbusch, "Family Influences on Dropout Behavior in One California High School," *Sociol. Educ.*, vol. 63, no. 4, p. 283, 1990, doi: 10.2307/2112876.

[38] L. Bonaldo and L. N. Pereira, "Dropout: Demographic Profile of Brazilian University Students," *Procedia - Soc. Behav. Sci.*, vol. 228, no. June, pp. 138–143, 2016, doi: 10.1016/j.sbspro.2016.07.020.

[39] E. Ghignoni, "Family background and university dropouts during the crisis: the case of Italy," *High. Educ.*, vol. 73, no. 1, pp. 127–151, 2017, doi: 10.1007/s10734-016-0004-1.

[40] P. Belley, M. Frenette, and L. Lochner, "Post-secondary attendance by parental income in the U.S. and Canada: Do financial aid policies explain the differences?," *Can. J. Econ.*, vol. 47, no. 2, pp. 664–696, 2014, doi: 10.1111/caje.12088.

[41] K. R. Alvarez, S. C. Alves, and R. P. Matos, "Evasão escolar nos cursos técnicos integrados ao ensino médio da Rede Federal: Levantamento de fatores motivacionais e propostas de intervenção," *Res. Soc. Dev.*, vol. 10, no. 6, p. e12510615630, 2021, doi: 10.33448/rsd-v10i6.15630.

[42] A. Woodley and O. Simpson, "Student Dropout: the elephant in the room," *Online distance Educ. Towar. a Res. agenda*, no. February, p. 520, 2013.

[43] V. Tinto, "Dropout from Higher Education: A Theoretical Synthesis of Recent Research," *Rev. Educ. Res.*, vol. 45, no. 1, pp. 89–125, 1975, doi: 10.3102/00346543045001089.

[44] V. Hegde and P. P. Prageeth, "Higher education student dropout prediction and analysis through educational data mining," *Proc. 2nd Int. Conf. Inven. Syst. Control. ICISC 2018*, no. Icisc, pp. 694–699, 2018, doi: 10.1109/ICISC.2018.8398887.

[45] J. L. C. Ramos *et al.*, "Um Modelo Preditivo da Evasão dos Alunos na EAD a Partir dos Construtos da Teoria da Distância Transacional," *An. do XXVIII Simpósio Bras. Informática na Educ. (SBIE 2017)*, vol. 1, no. Cbie, p. 1227, 2017, doi: 10.5753/cbie.sbie.2017.1227.

[46] D. Steinman, "Educational Experiences and the Online Student," *TechTrends - Sept. 2007*, vol. 51, no. Ed. 5, pp. 46–52, 2007, [Online]. Available: https://www.proquest.com/openview/91f45c607b775082d3d51f2ca338abb8/1?pq-origsite=gscholar&cbl=40581#.

[47] E. Yukselturk, S. Ozekes, and Y. K. Türel, "Predicting Dropout Student: An Application of Data Mining Methods in an Online Education Program," *Eur. J. Open, Distance E-Learning*, vol. 17, no. 1, pp. 118–133, 2014, doi: 10.2478/eurodl-2014-0008.

[48] J. M. Bridgeland, J. J. DiIulio, and R. Balfanz, "On the front lines of schools: Perspectives of Teachers and Principals on the High School Dropout Problem," *Civ. Enterp. Peter D. Hart Res. Assoc. AT&T Found. Am. Promise Alliance*, no. June, p. 60, 2009, [Online]. Available: https://files.eric.ed.gov/fulltext/ED509755.pdf.

[49] N. Krawczyk, *O Ensino Médio no Brasil*, vol. Em questão. 2009.

[50] L. T. Fornari, "Re fl exões acerca da reprovação e evasão escolar e os determinantes do capital," pp. 112–124, 2010.

[51] L. R. Gonçalves, S. R. M. M. S. dos Passos, and Á. M. dos Passos, "Novos rumos para o ensino médio noturno: como e por que fazer?," *Ens. Avaliação e Políticas Públicas em Educ.*, vol. 13, no. 48, pp. 345–360, 2005, doi: 10.1590/s0104-40362005000300005.

[52] D. R. Cox, "Regression Models and Life-Tables," *J. R. Stat. Soc. Ser. B*, vol. 34, no. 2, pp. 187–2020, 1972, [Online]. Available: http://links.jstor.org/sici?sici=0035-9246%281972%2934%3A2%3C187%3ARMAL%3E2.0.CO%3B2-6.