pratica. Revista Multimédia de Investigação em Inovação Pedagógica e Práticas de e-LEARNING

PRATICA, VOL. 6 (3)
OUTUBRO 2023

E-SIMEDUCATIC: THE FIRST PROTOTYPE OF TRANSPOSITION "E-SIM"(PROGRAMMING) PEDAGOGICAL APPROACH FOR EDUCATION FIELD

E-SIMEDUCATIC: O PRIMEIRO PROTÓTIPO DA TRANSPOSIÇÃO DA ABORDAGEM PEDAGÓGICA "E-SIM"(PROGRAMMING) PARA A ÀREA DE EDUCAÇÃO

E-SIMEDUCATIC: EL PRIMER PROTOTIPO DE TRANSPOSICIÓN "E-SIM" (PROGRAMMING) ENFOQUE PEDAGÓGICO PARA EL CAMPO EDUCATIVO

Daniela Pedrosa[1] **[https://orcid.org/0000-0001-9536-4234]**

[1]*Universidade de Aveiro, Departamento de Educação e Psicologia & Centro de Investigação em Didática e Tecnologia na Formação de Formadores (CIDTFF), Portugal, dpedrosa@ua.pt*

Abstract

The e-Sim(Programming) pedagogical approach has been applied in Face-to-Face and Distance Learning contexts, contributing to supporting self and co-regulation of learning and in the transition from initial to advanced skills, in the Computer Programming field. However, their applicability and transposition in other fields have not been identified in the scientific literature.

This work aims to understand and describe how the "e-Sim" approach can be adopted in the field of Education. Design Science Research was adopted to develop the first prototype "e-SimEducaTIC", applied in "ICT and Basic Education" course, in a blended-learning format, of the Degree in Basic Education at the University of Aveiro. Decisions, the type of adaptations implemented, and the challenges encountered in this process are described in this article.

It is concluded that it is possible to adapt the "e-Sim" approach. However, the transposition requires that the teacher adapts the dimensions of the "e-Sim" to the reality of their teaching context (pedagogical goals, expected skills, typology, and mode of operation of the course, etc.). It can be necessary to adjust procedures, given the knowledge and mastery of the techniques suggested by the "e-Sim" approach and the time-effort available to make the changes. Some recommendations are provided for educators and researchers who wish to adopt the approach in their teaching context.

Keywords: active learning approach, teaching pratices, SimProgramming approach, e-Sim, education.

Resumo

A abordagem pedagógica e-Sim(Programming) tem vindo a ser aplicada em contexto presencial e no Ensino a Distância, contribuindo no apoio à auto e corregulação das aprendizagens e na transição de competências iniciais para avançadas, na área de Programação de Computadores. Contudo, a sua aplicabilidade e transposição noutras áreas não foram identificadas na literatura científica.

Este trabalho tem como objetivos compreender e descrever como a abordagem "e-Sim" pode ser adotada na área de Educação. Adotou-se como metodologia de investigação *Design Science* para desenvolver o primeiro protótipo "e-SimEducaTIC", aplicado na disciplina de "TIC e Educação Básica", em contexto de blended-learning, da Licenciatura em Educação Básica da Universidade de Aveiro. Neste artigo, descreve-se as decisões, o tipo de adaptações implementadas e os desafios encontrados neste processo.

Conclui-se que é possível a adaptar a abordagem "e-Sim". Porém, a sua transposição requer que o docente adeque as dimensões da "e-Sim" à realidade do seu contexto letivo (objetivos pedagógicos, as competências esperadas, a tipologia e modo de funcionamento da UC, etc.). Pode ter de ajustar procedimentos, face aos seus conhecimentos e domínio das técnicas sugeridas pela abordagem "e-Sim" e ao tempo-esforço disponível para proceder as alterações.

Fornece-se algumas recomendações para educadores e investigadores que pretendam adotar a abordagem no seu contexto letivo.

Palavras-chave: Abordagem de aprendizagem ativa, práticas de ensino, abordagem SimProgramming, e-Sim, educação.

Resumen

El enfoque pedagógico e-Sim(Programming) se ha aplicado en un contexto presencial y en Educación a Distancia, contribuyendo al apoyo de la autorregulación y corregulación del aprendizaje y en la transición de habilidades iniciales a avanzadas, en el área de Programación Informática. Sin embargo, su aplicabilidad y transposición en otras áreas no ha sido identificada en la literatura científica.

Este trabajo tiene como objetivo comprender y describir cómo se puede adoptar el enfoque "e-Sim" en el campo de la Educación. Se adoptó la Ciencia del Diseño como metodología de investigación para desarrollar el primer prototipo "e-SimEducaTIC", aplicado en la asignatura de "TIC y Educación Básica", en un contexto semipresencial, de la Licenciatura en Educación Básica de la Universidad de Aveiro. Se describen las decisiones, el tipo de adaptaciones implementadas y los desafíos encontrados en este proceso.

Se concluye que es posible adaptar el enfoque "e-Sim". Sin embargo, su transposición requiere que el docente adapte las dimensiones de la "e-Sim" a la realidad de su contexto docente (objetivos pedagógicos, competencias esperadas, tipología y modo de funcionamiento de la UC, etc.). Es posible que deba ajustar los procedimientos, dado su conocimiento y dominio de las técnicas sugeridas por el enfoque "e-Sim" y el tiempo-esfuerzo disponible para realizar los cambios. Se proporcionan algunas recomendaciones para educadores e investigadores que deseen adoptar el enfoque en su contexto de enseñanza.

Palabras-clave:. enfoque de aprendizaje activo, prácticas de enseñanza, enfoque SimProgramming, e-Sim, educación.

INTRODUCTION

The use of digital resources and media in teaching is increasingly important for improving education quality (Tondeur, 2018; Galindo-Domínguez, 2021). Digital competence requires cognitive, emotional, and sociological skills to effectively use digital environments (Reisoğlu, 2020). So, future teachers need to be digitally competent, integrating ICT into pedagogical practices, making responsible decisions, and promoting learning (Gudmundsdottir, 2020; Starkey, 2020).

The integration of ICT in teacher education is crucial, requiring the interaction of technology, content, and pedagogy (Dinçer, 2018). Also, professional development is necessary to enhance student teachers' digital skills and their ability to integrate ICT in pedagogical practices. The European Commission's DigCompEdu (Redecker, 2017) guidelines identify areas of competence to be developed, including self- and co-regulated learning. Self-regulated learning skills are important for active teacher learning, and co-regulation of learning provides social support and facilitates significant learning. Future teachers need support in developing self- and co-regulation of learning strategies, and teacher educators should design collaborative learning activities with clear goals and instructions (Saariaho et al., 2016). Teacher education needs to provide opportunities for develop self- and co-regulation of learning strategies.

The e-Sim (Programming) pedagogical approach has been shown to contribute to the support of self- and co-regulated learning and can be an opportunity (Pedrosa, Morgado Cravino, 2022).

1 E-SIM PEDAGOGICAL APPROACH

The "e-Sim" or "e-SimProgramming" approach was developed to address the complexities of teaching software engineering, which requires students to acquire technical knowledge and advanced cognitive and behavioral skills (Pedrosa, Morgado & Cravino, 2022). Over the past decade, extensive research work has been conducted to design, implement, and evaluate the "e-Sim" approach. This research includes both face-to-face courses (Morgado et al., 2012; Pedrosa et al., 2017; Nunes et al., 2021) and asynchronous e-learning courses (Pedrosa et al., 2020, 2021,

2022). The "e-Sim" approach is built upon four key foundations: 1) immersive learning, 2) self-regulation of learning, 3) co-regulation of learning, and 4) formative assessment (Pedrosa, Morgado & Cravino, 2022).

1.1 Immersive Learning

The "e-Sim" approach incorporates immersive learning, which encompasses three dimensions of immersion (Morgado, 2022; Beck, Morgado & O'Shea, 2020). Firstly, challenge/agency immersion promotes active engagement and interaction in learning through activities that require effort and participation, such as project-based learning. Secondly, narrative immersion utilizes storytelling elements to create meaningful pedagogical activities, with characters and plots motivating student involvement and role definition. The professor acts as a project coordinator, adapting the curriculum to the simulated environment. Lastly, system immersion aims to create a sense of presence and involvement in a simulated environment that mirrors the students' future professional context, adapting learning contexts based on available resources and conditions. Overall, the "e-Sim" approach recognizes the importance of immersion in all three dimensions to enhance the learning experience and prepare students for their future professional endeavors.

1.2 Self-regulated learning

Self-regulated learning (Pedrosa, 2022) involves designing activities that actively engage students in meaningful learning experiences aligned with real-world professional contexts. These activities can be completed individually or in teams, with the aim of developing study routines and self-regulation learning strategies (Zimmerman, 2013), such as: planning, organization, and management. Throughout the semester, students work on a continuous project divided into phases and stages, with regular tasks and formative feedback. They are also encouraged to participate in metacognitive challenges (Pedrosa, Morgado & Cravino, 2022b) that promote self-reflection, self-assessment, and the monitoring of their own learning process and individual goals.

1.3 Co-regulated learning

The co-regulated learning (Pedrosa, 2022) involves team projects and assigning roles to team members for specific tasks. Each student assumes a role and performs individual tasks that contribute to the overall project perspective (Harley, Taub, Bouchet, & Azevedo, 2012). Teams are responsible for self-organization, task assignment, and clearly defining member roles (Panadero & Järvelä, 2015; Zheng & Huang, 2016). In the context of immersive learning, co-regulation occurs within a simulated professional environment where roles are played by both the teacher and the students. Responsibilities are distributed based on the defined roles, and regular sharing and debates among teams promote dialogue, reflection, and project improvement.

1.4 Formative Assessment

The formative assessment (Faria et al, 2023) assumes that a "pedagogical contract" is established between professors and students, emphasizing their involvement in the formative assessment process. The expectations and objectives of the learning process are clarified, considering factors such as time schedule, organization, and norms of the educational context. The professor takes on the role of structuring tasks, monitoring learning evidence, and providing feedback to ensure the achievement of learning objectives. Various strategies, including analyzing dynamics and interactions on platforms, assessing responses to metacognitive challenges, evaluating oral feedback and presentations, and reviewing written reports, are employed to collect and analyze evidence. Based on these analyses, the professor offers formative feedback to support and guide students. Predefined milestones and scheduling help facilitate the monitoring and assessment process, with specific analysis priorities defined at each stage.

2 PEDAGOGICAL CONTEXT

"ICT and Basic Education" ("TIC e EB", in Portuguese-language acronym) is an optional course in the Basic Education undergraduate program at the University of Aveiro in Portugal. It takes place in the 2nd semester of the 3rd year during the 2022/2023 academic year and carries 4 ECTS credits. The course aims to develop students' digital competences and pedagogical knowledge by engaging them in a project that integrates and explores ICT in Basic

education. It follows a blended learning approach, combining face-to-face classes, synchronous sessions via videoconference (colibri-zoom), and asynchronous activities on the LMS - Moodle and seesaw platforms. The course spans 13 weeks and includes presential/online classes, practical workshops with guest speakers, and autonomous work sessions. Project-Based Learning (PBL) (Kokotsaki, Menzie & Wiggins, 2016) is employed, involving five phases where teams of students develop an educational integration project of ICT with a curriculum content from Preschool Education or Basic Education. The teams present project status updates, submit parts of the report/project, and engage in metacognitive challenges (Pedrosa, Morgado & Cravino, 2022). In the 2022/2023 academic year, 22 students, including 4 Erasmus+ students, were enrolled, and formed six teams. The teams had the freedom to choose their project themes, covering various levels of Basic Education.

3 METHODOLOGY – DESIGN SCIENCE RESEARCH

This study adopted an iterative design science research cycle (Hevner, Chatterjee, Hevner & Chatterjee, 2010; Peffers, Tuunanen, Rothenberger & Chatterjee, 2007) to develop the initial prototype of the "e-Sim" approach for the field of Education. The subsections that follow describe how the approach was adapted and adjusted to accommodate the unique characteristics of the pedagogical context and the blended learning teaching modality.

3.1 Identify problem, motivation and goals

In the previous edition of the "TIC e EB" (in 2021/2022 academic year), it was identified that some SCRL strategies were not reported by the teams in the metacognitive challenges (Pedrosa, 2023). Therefore, it was recommended that future editions design activities that allow teams to develop these strategies (ibid.).

The e-Sim approach has previously been shown in the context of teaching programming to support students' SCRL. However, in May 2023, a search was conducted through scientific publication databases such as SCOPUS, WoS, Scholar, and ERIC using the search terms "e-SimProgramming," "SimProgramming," and "SimProgramming approach." The results indicated that the approach has only been implemented in the original context of teaching programming, with no identified implementation in other areas of knowledge.

This study intended to create and test a first prototype of an "e-Sim" approach was designed for the context of Education field for developing self- and co-regulated learning strategies.

3.2 Demonstration: Planning and Implementation

The "e-Sim" approach recommends aligning pedagogical goals with Bloom's revised taxonomy (Krathwohl, 2002) and incorporating immersive narrative techniques, such as OC2-RD2 and Puzzle-triggers (Fontes et al., 2021). This prototype of "e-SimEducaTIC," time constraints and the need to deepen knowledge about structured narrative techniques led to a decision to plan activities based on the existing goals of the "TIC e EB" course, while maintaining project-based learning and focusing on ICT integration projects within Pre-School Education or Basic Education.

The reformulation made in relation to previous editions of the "TIC e EB" provided a more structured clarification of what is expected in each phase of the project development. Clear indications of the expectations for each phase have been included (in previous editions, students autonomously developed the project without the obligation to deliver that specific component). Additionally, task delivery stages have been integrated with each other (Table 1).

The "e-Sim" approach emphasizes the importance of culturally relevant immersive narratives that create a sense of realism. This prototype of "e-SimEducaTIC," narratives were crafted to immerse students in a storyline set within an ICT Competence Center (ERTE - Direção Geral da Educação, s.d) in Basic Education (Figure 1). The learning activities were designed to align with this narrative sequence.

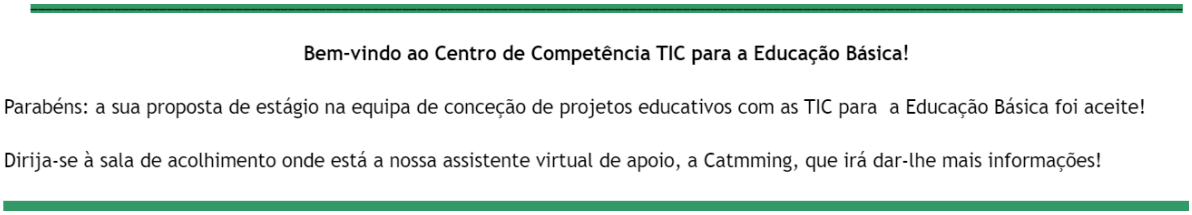
Table 1

e-SimEducaTIC phases: goals, specifics tasks and duration.

e-SimEducaTIC Phases	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Assignment goals	Draft Elaboration – Searching for information and drafting the project.	Planning – Elaboration of the pedagogical plans of the project activities.	Development – Planning and creation of digital educational resources.	Development – Definition of assessment instruments and methods	Final improvement of all Project.
Specifics Tasks	Presentation 1 Report – Draft of project Metacognitive challenges (MC) (Individual and team) Participation in community of practice (seesaw and Moodle)	Presentation 2 Report – Pedagogical plans MC (Individual and team) Participation in community of practice (seesaw and Moodle)	Presentation 3 Report – Digital educational materials and resources MC (Individual and team) Participation in community of practice (seesaw and Moodle)	Presentation 4 Report – Assessment Methodology MC (Individual and team) Participation in community of practice (seesaw and Moodle)	Final Presentation Final Project MC (Individual and team) Participation in community of practice (seesaw and Moodle) Self and hetero assessment
Duration	3 weeks	3 weeks	3 weeks	2 weeks	2 weeks

Figure 1

"Welcome to CCTICEB" message on the Moodle platform – Simulation of the learning environment.



The immersive narrative of the "e-SimEducaTIC" prototype is set in an ICT Competence Center ("CCTICEB") where students collaborate in teams to develop ICT projects in education. The narrative features six characters with traditional Portuguese names: António, Amélia, João, and Maria. The virtual assistant, Catmming was kept, is an AI integrated into the immersive simulation environment. The professor is referred to as the "CCTICEB Coordinator." The original archetypes for the characters were maintained (Table 2), as described in Fontes et al. (2021) and Castelhano et al. (2021).

Table 2

Character archetypes.

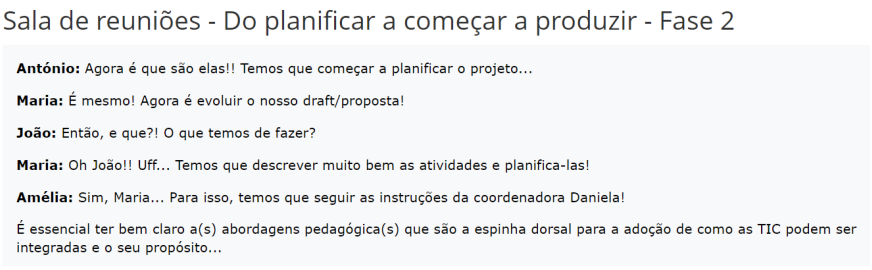
Character Description	In e-SimProgramming	In e-SimEducaTIC
Artificial intelligence has the role of encouraging students to reflect and become aware of their learning process throughout the course, through metacognitive challenges.	Catmming	Catmming
Leader and provides the necessary guidelines for the development of projects. Typically, this role is assumed by the professor.	Boss	Coordinator of CCTICEB
It represents an individual who is impulsive in his decisions.	Meia-bola	João
Represents an individual who is enthusiastic and receptive but is characterized by not doing much.	Patavinas	António
A character characterized by being hardworking, enterprising and for fulfilling the defined goals.	Ada	Amélia
Sociable character, and that shows great conviction, and fosters group cohesion.	Fezada	Maria

Due to time constraints, the creation of narratives in the "e-SimEducaTIC" prototype did not follow the suggested OC2-RD2 technique. Instead, narratives were developed as a sequence of dialogues and recommendations by characters, guiding students on the expected tasks for each project phase and aligning them with the pedagogical goals (Figure 2). The inclusion of a task list after each narrative section, as suggested in the original "e-Sim" approach in programming, was maintained. This task list serves as a reminder to students of the specific tasks they need to accomplish, providing clarity, especially if they have difficulty understanding the narrative.

Role-playing activities were incorporated during face-to-face sessions, with the professor assuming the role of the coordinator and treating students as "interns" to create an immersive experience. The professor used glasses as an accessory to simulate the role. During the practical workshops conducted by external trainers, the professor simulated being also as participant in a training session.

Figure 2

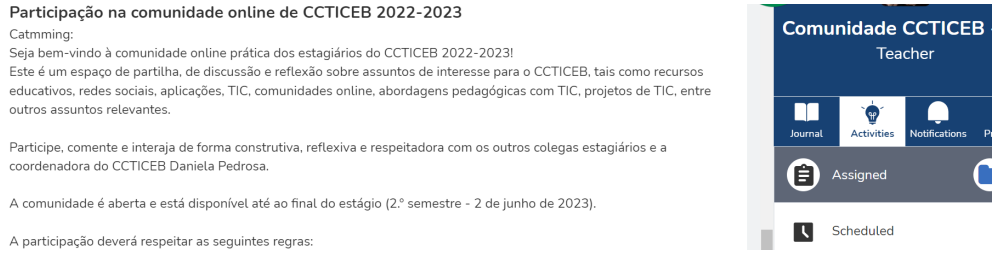
Example of narrative from Phase 2 with guidelines for students.



Work submissions on the Moodle platform were transformed into simulated "meeting rooms" or "work file rooms" to immerse students in the context. The Moodle platform itself simulated integration within the CCTICEB, with the course organized into five project development phases. Reflective activities, including metacognitive challenges, were represented as simulated spaces within a meeting room where the virtual assistant, Catmming, facilitated reflection on the learning process and self-regulated learning. In addition, a virtual community of practice was established using the Seesaw platform to encourage educators to share and discuss ideas related to ICT in education, replicating real-life interactions and collaboration among educational professionals (Figure 3).

Figure 3

Simulation of virtual community of practice.



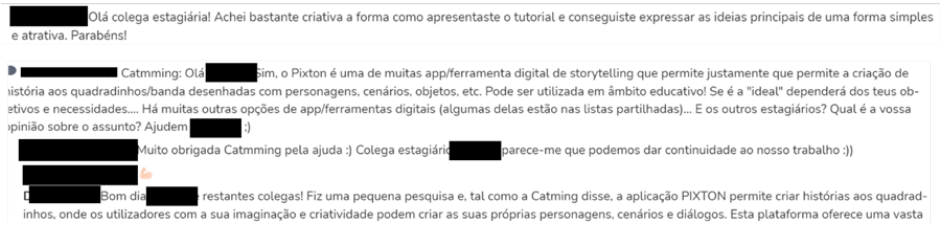
Professor monitoring and evaluation techniques were implemented to support SCRL in the "TIC e EB" course. The approaches included weekly monitoring of the online community to track student participation and provide motivational messages for engagement. The Professor also followed up on assignment submissions, allowing a grace period for late submissions and sending reminders to teams who failed to submit their tasks. Oral feedback was provided during project presentations, encouraging peer feedback and discussion. In phase 3, the teacher offered written feedback to guide improvements for the final project. Due to the b-learning format and the need for data gathering and analysis, the creation of manual or computerized dashboards was not feasible in this version of "e-SimEducaTIC." The refinement of indicators and analytical methods will be addressed in future prototypes.

4 PRELIMINARY RESULTS AND REFLECTIONS

Preliminary results of applying the "e-Sim" approach in the "TIC and EB" course showed positive outcomes in immersive learning. Students actively engaged in role-playing as interns, demonstrated through their participation in face-to-face classes and interactions on learning support platforms. The engagement among classmates, the Professor as the Coordinator, and the fictional character *AI Catmming* was observed and documented (Figure 4).

Figure 4

Examples of immersive student dialogues.



In terms of SCRL, most teams consistently submitted tasks on time, with only a few requiring additional interventions. However, there were two teams that required additional teaching intervention. One team consisted of Erasmus+ students who required personalized monitoring, and the other team had a smaller composition with only two members. Individual students generally responded to metacognitive challenges within deadlines, although there was a minor gap between phases. However, there was a minor gap between phases, potentially due to forgetfulness or difficulty in verifying whether the responses were successfully submitted in Moodle. As a potential improvement for future editions, providing an instruction guide to explain to students how to submit their response.

The regularity and quality of project presentations suggest effective learning strategies. However, as the course is still ongoing, a comprehensive analysis of SCRL will be conducted in future studies to address potential issues and provide further insights.

In the simulated online community (Seesaw), students demonstrated active and regular participation. As of May 2023, approximately 63 original posts were recorded, with students actively commenting and interacting with each

other. On average, each post received 3 to 6 responses. Participation slightly decreased over time, which students attributed to deadlines for assignments in other subjects. Clear deadlines and participation rules for task submissions in the community were established. The initial teaching intervention likely contributed to fostering positive engagement.

The challenges encountered in implementing the "e-Sim" approach included the creation of immersive narratives that aligned with the nature and goals of the course. The decision was made to focus on providing support and guidance through narratives for the tasks, rather than delivering programmed content through lectures. In future iterations, with more know-how in creating immersive narratives, the goal is developing narratives with greater complexity and content. An aspect that was not addressed in previous "e-Sim" prototypes but was identified in this test was the inclusion of foreign students, such as Erasmus+ students, who are not native speakers of the language in which the narratives were originally conceived. To address this, personalized interventions were conducted to explain the content of the narratives and ensure their understanding.

Also, the need to monitor and track students' learning activities taking place in different spaces (online: Moodle and Seesaw platforms; face-to-face: where the teacher lacks control or registration of student activities). As a result, there is a need to identify and map indicators for monitoring student activity to ensure timely and tailored interventions. The monitoring techniques described in the previous section have proven to be effective. However, it should be noted that regular and active monitoring of students was achieved due to the manageable class size (n=22) and the focus on group activities. In larger classes, a monitoring panel would be a valuable tool. Regular monitoring of the online community also posed a challenge, suggesting the potential adoption of Peer Assessment Techniques for formative feedback.

Adapting the "e-Sim" approach to different educational realities is feasible but requires adaptation to specific contexts, considering pedagogical goals, competences, course format, and institutional guidelines. Although some procedures may require deeper knowledge and understanding to be effectively applied, it is recommended to find a balance between the available time and effort to make changes, while also being aware that it may not be possible to implement everything in the first edition. It is important to note that the "e-Sim" approach has been developed over years of research by a multidisciplinary team.

Participating in future training sessions on the "e-Sim" approach can enhance educators' understanding of how to adopt the approach in their specific context. Overall, the "e-Sim" approach contributes to immersing students in a simulated real-world context and stimulates the development of self- and co-regulated learning.

In future work, ERICA (Kaplan et al., 2017) questionnaire (pre and post intervention) that were applied will be analyzed to verify how the approach influenced the SCRL, and the questionnaire that assess students' perceptions qualitatively and quantitatively. Also, it will deep data analysis to verify the effectiveness of the E-Sim approach.

ACKNOWLEDGMENTS

This work is financially supported by National Funds through FCT – Fundação pa-ra a Ciência e a Tecnologia, I.P., under the project UIDB/00194/2020.

D. Pedrosa wishes to thank FCT and CIDTFF - Universidade de Aveiro, Portugal, for Stimulus of Scientific Employment – CEECIND/00986/2017 Individual Support 2017.

Thank all the students who collaborated on this research.

REFERENCES

Beck, D., Morgado, L., & O'Shea, P. (2020). Finding the gaps about uses of immersive learning environments: a survey of surveys. *Journal of Universal Computer Science*, 26, 1043-1073. Doi: 10.3897/jucs.2020.055

Castelhano, M., Araújo, T., Pedrosa, D., Morgado, L., Cravino, J. (2021). Ambientes com narrativas imersivas através da técnica OC2-RD2 no Ensino de Programação de Computadores no Ensino Superior a Distância: perceções dos estudantes sobre os nomes das personagens. In A. Osório, M. Gomes, A. Ramos, A. Valente (eds.), *XII Conferência Internacional de Tecnologias de Informação e Comunicação na Educação - Challenges 2021, Desafios do Digital: Livro de atas* (1.ªedição, pp. 589-600). Universidade do Minho – Centro de competências.

Dinçer, S. (2018). Are preservice teachers really literate enough to integrate technology in their classroom practice? Determining the technology literacy level of preservice teachers. *Education and Information Technologies*, 23(6), 2699–2718. DOI: https://doi.org/10.1007/s10639-018-9737-z

ERTE-Direção Geral de Educação (s.d). Centro de competências TIC. https://erte.dge.mec.pt/centros-de-competencia-tic

Faria, R., Faria, F., Lopes, B., Pedrosa, D. (2022). 2.3 Avaliação formativa na abordagem e-simprogramming. In *Pedrosa, L. Morgado, J. Cravino (org.), e-SimProgramming: planificar, conceber e acompanhar atividades didáticas online de engenharia de software*. Lisboa: Universidade Aberta, 2022. (eUAb. Universitária; 32). ISBN 978-972-674. https://doi.org/10.34627/uab.cu.32

Fontes, M. M., Pedrosa, D., Araújo, T., Morais, C., Costa, A., Cravino, J., & Morgado, L. (2021). Narrative-Driven Immersion and Students' Perceptions in an Online Software Programming Course. *In 2021 7th International Conference of the Immersive Learning Research Network (iLRN)* (pp. 1-8). IEEE. doi: 10.23919/iLRN52045.2021.9459381

Galindo-Domínguez, H., & Bezanilla, M. J. (2021). Digital competence in the training of pre-service teachers: Perceptions of students in the degrees of early childhood education and primary education. *Journal of Digital Learning in Teacher Education*, 37(4), 262-278. DOI: https://doi.org/10.1080/21532974.2021.1934757

Gudmundsdottir, G. B., Gassó, H. H., Rubio, J. C. C., & Hatlevik, O. E. (2020). Student teachers' responsible use of ICT: Examining two samples in Spain and Norway. *Computers & Education*, 152, 103877. DOI: https://doi.org/10.1016/j.compedu.2020.103877

Harley, J., Taub, M., Bouchet, F., & Azevedo, R. (2012). A framework to understand the nature of co-regulated learning in human-pedagogical agent interactions. In *11th International Conference on Intelligent Tutoring Systems*, Crete.

Hevner, A., Chatterjee, S., Hevner, A., & Chatterjee, S. (2010). *Design science research in information systems. Design research in information systems: theory and practice*, 9-22. DOI: https://doi.org/10.1007/978-1-4419-5653-8

Kaplan, J., de Montalembert, M., Laurent, P., & Fenouillet, F. (2017). ERICA—an instrument to measure individual and collective regulation of learning. *European Review of Applied Psychology*, *67*(2), 79-89. DOI: https://doi.org/10.1016/j.erap.2017.01.001

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice*, 41(4), 212-218. DOI: https://doi.org/10.1207/s15430421tip4104_2

Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literature. *Improving schools*, 19(3), 267-277. DOI: https://doi.org/10.1177/1365480216659733

Morgado, L. (2022). Aprendizagem imersiva. In *D. Pedrosa, J. P. Cravino, & L. Morgado (Eds.), E-SimProgramming: Planificar, conceber e acompanhar atividades didáticas online de engenharia de software* (sec. sec. 2.1). Universidade Aberta. http://hdl.handle. net/10400.2/12731

Morgado, L., Fonseca, B., Martins, P., Paredes, H., Cruz, G., Maia, A. M., Nunes, R., & Santos, A. (2012). Social networks, microblogging, virtual worlds, and Web 2.0 in the teaching of programming techniques for software engineering: A trial combining collaboration and social interaction beyond college. In *Proceedings of the 2012 IEEE Global Engineering Education Conference (EDUCON)* (pp. 1-7). IEEE. doi: 10.1109/EDUCON.2012.6201129.

Nunes, R.R., Cruz, G., Pedrosa, D., Maia, A., Morgado, L., Paredes, H., Cravino, J., & Martins, P. (2021). Motivating Students to Learn Computer Programming in Higher Education: The SimProgramming Approach. In *A. Reis, J. Barroso, J.B. Lopes, T. Mikropoulos, C.W. Fan (eds.), Technology and Innovation in Learning, Teaching and Education. TECH-EDU 2020. Communications in Computer and Information Science* (vol 1384, pp. 506-518). Springer. DOI: https://doi.org/10.1007/978-3-030-73988-1_41

Panadero, E., & Järvelä, S. (2015). Socially shared regulation of learning: A review. *European Psychologist*. Doi: 10.1027/1016-9040/a00022 .

Pedrosa, D. (2022). 2.2 Autorregulação e corregulação da aprendizagem. In *Pedrosa, L. Morgado, J. Cravino (org.), e-SimProgramming: planificar, conceber e acompanhar atividades didáticas online de engenharia de software.* Lisboa: Universidade Aberta, 2022. (eUAb. Universitária; 32). ISBN 978-972-674. https://doi.org/10.34627/uab.cu.32

Pedrosa, D. (2023, in press). Co-regulated learning in initial teacher education: Strategies adopted by students during the development of ICT integration projects in Basic Education. In *Proceedings Moving on Towards 'New Normal' In Education - ICEM2022 Conference*. SPRINGER

Pedrosa, D., Morgado, L., Cravino, J. (2022). *e-SimProgramming: planificar, conceber e acompanhar atividades didáticas online de engenharia de software*. Lisboa: Universidade Aberta, 2022. (eUAb. Universitária; 32). ISBN 978-972-674. https://doi.org/10.34627/uab.cu.32

Pedrosa, D., Morgado, L., Cravino, J., Fontes, M. M., Castelhano, M., Machado, C., & Curado, E. (2020). Challenges Implementing the SimProgramming Approach in Online Software Engineering Education for Promoting Self and Co-regulation of Learning. In *2020 6th International Conference of the Immersive Learning Research Network (iLRN)* (pp. 236-242). IEEE. Doi: 10.23919/iLRN47897.2020.9155183.

Pedrosa, D., Cravino, J., Morgado, L., & Barreira, C. (2017b). Self-regulated learning in higher education: strategies adopted by computer programming students when supported by the SimProgramming approach. *Production*, 27(spe), e20162255. DOI: https://doi.org/10.1590/0103-6513.225516

Pedrosa, D., Morgado, L., & Cravino, J. (2022b). A strategy to support Engineering Education teaching staff monitoring students' learning process: Metacognitive Challenges. In *International Symposium on Project Approaches in Engineering Education; Active Learn-ing in Engineering Education Workshop; International Conference on Active Learning in Engineering Education (PAEE/ALE'2022)* (pp. 295-303). Department of Production and Systems. PAEE Association School of Engineering of University of Minho. DOI: 10.5281/zenodo.7062198

Peffers, K., Tuunanen, T., Rothenberger, M. A., & Chatterjee, S. (2007). A design science research methodology for information systems research. *Journal of management information systems*, 24(3), 45-77. DOI: https://doi.org/10.2753/MIS0742-1222240302

Redecker (2017). *European Framework for the Digital Competence of Educators: DigCompEdu*, Y. Punie, Ed. Luxembourg City, Luxembourg: Publications Office of the European Union. DOI: 10.2760/159770

Reisoğlu, İ., & Çebi, A. (2020). How can the digital competences of pre-service teachers be developed? Examining a case study through the lens of DigComp and DigCompEdu. *Computers & Education*, *156*, 103940. DOI: https://doi.org/10.1016/j.compedu.2020.103940

Saariaho, E., Pyhältö, K., Toom, A., Pietarinen, J., & Soini, T. (2016). Student teachers' self-and co-regulation of learning during teacher education. *Learning: Research and Practice*, 2(1), 44-63. DOI: https://doi.org/10.1080/23735082.2015.1081395

Starkey, L. (2020). A review of research exploring teacher preparation for the digital age. *Cambridge Journal of Education*, 50(1), 37-56. DOI: https://doi.org/10.1080/0305764X.2019.1625867

Tondeur, J., Aesaert, K., Prestridge, S., & Consuegra, E. (2018). A multilevel analysis of what matters in the training of pre-service teacher's ICT competencies. *Computers & Education*, *122*, 32-42. DOI: https://doi.org/10.1016/j.compedu.2018.03.002

Zheng, L., & Huang, R. (2016). The effects of sentiments and co-regulation on group performance in computer supported collaborative learning. *The Internet and Higher Education*, *28*, 59-67. DOI: https://doi.org/10.1016/j.iheduc.2015.10.001

Zimmerman, B. J. (2013). From cognitive modeling to self-regulation: A social cognitive career path. *Educational psychologist*, *48*(3), 135-147. DOI: https://doi.org/10.1080/00461520.2013.794676