

# EDULEARN<sup>23</sup>

**15TH INTERNATIONAL CONFERENCE  
ON EDUCATION AND NEW LEARNING  
TECHNOLOGIES**

**PALMA (SPAIN)  
3RD-5TH OF JULY, 2023**



## CONFERENCE PROCEEDINGS



# **EDULEARN<sub>23</sub>**

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**CONFERENCE  
PROCEEDINGS**

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**Edited by**

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## **Preface**

Welcome to the conference proceedings of EDULEARN23. This compilation of papers and research findings were written by a diverse array of education experts and scholars who participated in the 15th EDULEARN conference, held in Palma, Spain from the 3rd to the 5th of July 2023. The conference brought together academics and researchers from the field of education to exchange knowledge, inspire new ideas and share their insights.

The theme of EDULEARN23 covers the fields of education and educational research. EDULEARN23 provided different keynote speeches, parallel thematic sessions, networking activities, workshops, and interactive sessions. The extensive number of international experts who attended the conference allowed attendees to network and share innovative ideas, promoting cross-country collaboration. The keynote speeches are available at IATED Talks ([iated.org/talks/](https://iated.org/talks/)).

The EDULEARN23 Proceedings, which are exclusively in English, include the accepted contributions presented at the EDULEARN Conference, which will be included in the IATED Digital Library ([library.iated.org](https://library.iated.org)). They represent the collective efforts of the authors to advance knowledge in their field. The EDULEARN23 International Program Committee is composed of lecturers and researchers from many different countries. A blind peer review process was followed in order to guarantee the quality and relevance of the final publication. During this process, the following points were evaluated: information content, relevance to the educational field, general structure, clarity of contents, originality, and relation to the conference topics and disciplines.

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We extend our sincere gratitude to all the authors who submitted their valuable work to these EDULEARN23 Proceedings. We also wish to express our gratitude to all participants and attendees for their engagement, dedication, and passion for education.

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## EDULEARN23 Keynote Speakers

### Keynote Speakers

Ashok K. Goel – *Georgia Institute of Technology, United States*

Donald Clark – *Wildfire, United Kingdom*

### Ashok K. Goel – Georgia Institute of Technology (USA)



*Keynote speech:  
Teaching and Learning in the Age of AI*

Millions of adults of various ages need reskilling and upskilling in our technological society. These millions of adult learners offer a new, large, and diverse challenge to education. Given that many adult learners cannot leave their jobs or families, online education offers a medium for reaching them where they live and work. Online education also provides access to unprecedented amount of data on learners and learning. Our vision at the National AI Institute for Adult Learning and Online Education (AI-ALOE) is to develop novel AI cognitive assistants that work with this data to enhance the quality of adult online learning through personalization of learning. Successful realization of this vision requires progress on understanding the motivations, needs, and capacities of adult learners, participatory design of AI cognitive assistants, human-AI collaboration, large-scale learning analytics, and an infrastructure for deploying the AI cognitive assistants, collecting and analyzing the data on learning, and feeding the results to the cognitive assistants, teachers, and learners alike. I will describe the research program at AI-ALOE in some detail.

#### *Biography:*

Ashok K. Goel is a Professor of Computer Science and Human-Centered Computing in the School of Interactive Computing at Georgia Institute of Technology, and the Chief Scientist with Georgia Tech's Center for 21st Century Universities. For more than thirty-five years, he has conducted research into cognitive systems at the intersection of artificial intelligence and cognitive science with a focus on computational design and creativity. For the last decade or so, much of his research has focused on AI in education and education in AI. He is a Fellow of AAAI and the Cognitive Science Society, an editor emeritus of AAAI's AI Magazine, and a recipient of AAAI's Outstanding AI Educator Award. Ashok is the Executive Director of the recently established National AI Institute for Adult Learning and Online Education.

## Donald Clark – Wildfire (UK)



*Keynote speech:  
AI changes everything!*

Generative AI will change the way we work, therefore what, why and how we learn. Its profound impact on both work and learning will be presented showing that the consequences are both profound and unexpected. The role of the teacher and upskilling will also be explored.

*Biography:*

Donald Clark is a Learning Tech Entrepreneur, CEO, Researcher, Blogger and Speaker. He was CEO and one of the original founders of Epic Group plc, which established itself as the leading company in the UK online learning market, floated on the Stock Market in 1996 and sold in 2005. He has been involved at all levels of investment – angel, VC, growth, PE and IPO. As well as being the CEO of Wildfire an AI learning company, he also invests in, and advises, EdTech companies.

An investor and board member of learning companies Cogbooks (sold in 2021 to Cambridge University) and Learning Pool (sold 2021 for \$200 million), he was also on the Boards of City & Guilds, Learn Direct, University for Industry and the Brighton Dome and Festival. Wildfire delivers AI products and consultancy. He has published 3 books, the first on AI, second on Design for technology and the third, published next month on Learning Technology. His fourth book on Learning in the Metaverse has just been commissioned.

Donald has over 37 years' experience in online learning, video, games, simulations, adaptive, chatbot, social media, mobile learning, virtual reality and AI projects. He has designed, delivered and advised on online learning for many global, public and private organisations. An evangelist for the use of technology in learning, he has won many awards, including the first 'Outstanding Achievement in E-learning Award' and 'Best AIM Stock Market Company', 'Most Innovative Online Product', 'Best Online Learning Project and 'JISC EdTech Award'.

An award winning speaker at national and international conferences, he has delivered keynotes in the UK, Europe, US, Africa, Australia, Middle and Far East.

..... also a regular blogger (15 years+) on learning technology.

## Conference Tracks & Sessions

The EDULEARN23 conference program is available online at <https://iased.org/edulearn23>

### ORAL SESSIONS MONDAY

Technology-enhanced Learning  
Computational Thinking Skills for the Digital Age  
Soft Skills & Socio-Emotional Learning  
Adapting Education in the Post-Pandemic Era  
Programming and Computer Science Education  
Experiences in Primary & Secondary Education  
Experiences in Tourism Education  
Technology-Enhanced Mathematics Education  
Virtual Reality in Education  
Creativity & Critical Thinking  
Assessment and Evaluation Strategies (1)  
Impact of COVID-19 on Education  
Integrating Robotics and Programming in Educational Settings  
STEM Education in Schools (1)  
Technology-enhanced Language Learning  
Teaching STEM Subjects  
Generative AI for Innovative Teaching and Learning  
Game-Based Learning  
e-Assessment  
Innovative Tools for Learning  
Experiences in Engineering Education  
Inclusive Education  
Language Teaching and Learning  
Experiences and Innovations in Mathematics Education (1)  
AI in Education  
Project and Problem Based Learning  
Assessment and Evaluation Strategies (2)  
Videos for Learning  
Digital and Media Literacy  
Supporting Special Education  
English for Special Purposes & English as a Medium of Instruction  
Experiences and Innovations in Mathematics Education (2)

### POSTER SESSIONS MONDAY

Pedagogical Innovations and Trends in Education  
Emerging Technologies in Education

### ORAL SESSIONS TUESDAY

Social Media & Digital Skills  
Plagiarism and Academic Dishonesty  
e-Portfolios & Reflective Assessment  
Experiences in Higher and Further Education  
Professional Development of Teachers (1)  
Student and Teacher Wellbeing  
Experiences in Business Education  
Service Learning & Community Engagement  
Integrating Virtual Reality in Education  
Learning Analytics (1)

International Projects & Mobility Experiences  
Workplace & Lifelong Learning  
Professional Development of Teachers (2)  
Student Support  
Experiences in Health Sciences Education  
Education for Sustainability (2)  
Virtual & Augmented Reality  
Learning Analytics (2)  
Active and Experiential Learning  
Internships and Work-integrated Learning  
ICT Skills among Teachers  
Educational Management (1)  
New Technologies in Health Sciences Education  
STEM Education in Schools (2)  
m-Learning  
e-Learning Experiences  
Gamification and Game-Inspired Learning  
Personalized and Self-Regulated Learning  
Teacher Training  
Educational Management (2)  
English as a Foreign Language  
Innovations in STEM Education  
Chatbots & AI in Education  
From Face-to-Face to Remote Learning  
Blended & Hybrid Learning  
Entrepreneurship Education  
Pedagogical Innovations  
University-Industry Cooperation  
Education for Sustainability (1)  
Professional Development of STEM Teachers

## **POSTER SESSIONS TUESDAY**

Experiences in Education  
New Challenges in Education and Research

## **VIRTUAL SESSIONS**

### **DIGITAL TRANSFORMATION OF EDUCATION**

Data Science & AI in Education  
Learning Analytics & Educational Data Mining  
Digital Transformation  
Digital and Media Literacy  
Educational Programming & Robotics  
Computer Games and Educational Software

### **INNOVATIVE EDUCATIONAL TECHNOLOGIES**

AI, Chatbots & Robots  
Virtual & Augmented Reality  
Social Media in Education  
Technology Enhanced Learning  
Videos for Learning  
Simulation & 3D Technologies

### **DIGITAL & DISTANCE LEARNING**

Distance Education in COVID-19 Times  
Challenges and Practices during the Pandemic and Beyond  
Blended & Mobile Learning  
Open Educational Resources  
Learning Management Systems & Virtual Learning Environments

**ACTIVE & STUDENT-CENTERED LEARNING**

Gamification & Game-based Learning  
Experiential & Cooperative Learning  
Problem & Project-Based Learning  
Flipped & Hybrid Learning  
Pedagogical Innovations  
Creativity & Critical Thinking

**ASSESSMENT, MENTORING & STUDENT SUPPORT**

Assessment & Evaluation  
Mentoring & Tutoring  
Student Support & Motivation  
Developing Soft and Transversal Skills

**TEACHER TRAINING & ED. MANAGEMENT**

ICT & Digital Skills  
Professional Development of Teachers  
Educational Management

**QUALITY & IMPACT OF EDUCATION**

Quality in Education  
Experiences and Challenges in Curriculum Design  
Sustainability & Social Impact of Education  
Links between Education and Research  
University-Industry Collaboration  
Mobility & International Projects

**EDUCATIONAL STAGES & LIFE-LONG LEARNING**

Early Childhood & Primary Education  
Vocational Education  
Transition to the Job Market & Entrepreneurship  
Life-Long & Workplace Learning

**MULTICULTURALITY & INCLUSION**

Multicultural Education  
Diversity Issues  
Special Educational Needs  
Inclusive Education

**DISCIPLINE-ORIENTED SESSIONS**

Architecture & Interior Design Education  
Health Sciences Education  
Computer Science Education  
Business & Tourism Education

**LANGUAGE LEARNING AND TEACHING**

Foreign Languages  
Language Learning & Translation Studies  
New Technologies in Language Learning

**STEM EDUCATION**

Mathematics & Statistics  
Engineering Education  
STEM Experiences

# TEACHER TRAINING ON MOBILE AND GAME-BASED LEARNING: LITERATURE REVIEW AND TRAINING PROGRAM PROPOSAL

**Margarida M. Marques, Lúcia Pombo**

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of Education and Psychology, University of Aveiro (PORTUGAL)*

## **Abstract**

The integration of mobile and game-based technologies in teaching practices is challenging for teachers, as they have both pedagogical and technological issues to tackle and, frequently, do not have or have insufficient training in this specific area. The analysis of the literature in this field is relevant for sustaining decisions regarding both pre-service and in-service teacher training in mobile and game-based learning, and to suggest future lines of research. The objective of this contribution is to provide an overview of the approaches and type of resources considered suited for teacher training, as well as the empirical results obtained in those training initiatives. For that, a literature review was conducted following the 2020 research procedure of the “Preferred Reporting Items for Systematic Reviews and Meta-Analyses” (PRISMA). It involved searching and screening peer reviewed publications indexed in ERIC until 2022. The articles reviewed were related to teacher training focusing mobile learning or game-based learning, directed at primary and/or secondary teachers. The results revealed that teacher training approaches include the: 1) familiarization with digital tools that can be mobilized in teaching practices; 2) development of mobile and/or game-based learning resources; and 3) testing those resources with students. The digital tools explored in training were either previously existing software (e.g., Excel, Hot Potatoes, or Kahoot) or web-based tools developed specifically to support these innovative approaches. Overall, the training results obtained in the included studies were: 1) Trainees’ positive perceptions towards the integration of mobile/game-based learning in their (future) teaching practice; 2) Trainees’ acknowledgement of both advantages and constraints regarding these approaches; 3) Exploring mobile and/or game-based learning is a challenging task for (future) teachers; and 4) Teacher training is needed since pre-service courses, to support both pedagogical and technological issues regarding mobile and game-based learning. Considering the lack of research in the area of teacher training on mobile and game-based learning and the authors’ previous experience in this area, an accredited in-service teacher training is proposed. The training is directed at teachers from different subject areas, to support the development of cross-subjects work and it includes: 1) An initial contextualization on mobile and game-based learning, 2) A mobile gaming experience as if teachers were students, 3) Hands-on project of mobile game creation, including the development of educative multimedia resources; 4) Game testing with the trainees’ students; and 5) Game results’ analysis and reflection. Finally, the game produced during the training is made openly available to be useful to other teachers and students. This study is a first step to provide a state-of-the-art regarding teacher training on mobile and game-based learning. It reveals the lack of empirical studies reporting research on training approaches for primary and secondary teachers, particularly the training approaches, tools and results obtained. The main limitation of this study is the low number of studies that met the inclusion criteria, so future work must include other sources of scientific publication registers.

**Keywords:** In-service teacher training, pre-service teacher training, mobile learning, game-based learning, primary education, secondary education, literature review.

## **1 INTRODUCTION**

Digital learning environments have been gaining attention during the last few years, revealing a new paradigm where learners take control of their own learning. Mobile learning creates a venue to promote a culture of participation where learners and leaders can both engage in combined efforts with multiplicative outcomes of greater success [1]. The rising usage of mobile devices, including smartphones and tablets, has encouraged researchers to design and develop learning applications and games for such platforms [2]. In fact, when an educational game is made accessible via mobile devices, it opens up possibilities to promote individualized, anytime, and anywhere learning [1].

Mobile game-based learning has been applied in multiple areas and it is considered to be potentially effective in improving learning [3]. For educational purposes, the literature has been revealed the increased

engagement and motivation for learning [4]–[6], as well as students' enhanced understanding of scientific models and of complex concepts that are difficult to understand with traditional textbooks [7].

Also, teachers can take advantage of the pervasiveness of technological devices to innovate their educational practices and, therefore, to promote authentic learning, in formal, informal and non-formal settings [8]. When combined with emerging technologies, such as Augmented Reality (AR), mobile devices are claimed to also create conditions to promote students' engagement with learning in pre-service classroom teachers experiences with AR [9]. The recent proliferation of mobile devices and applications (app) makes AR technology accessible to support learning anytime and anywhere.

The integration of mobile and game-based technologies in teaching practices is challenging for teachers, as they have both pedagogical and technological issues to tackle and, frequently, do not have or have insufficient training in this specific area. The analysis of the literature in this field is relevant for sustaining decisions regarding both pre-service and in-service teacher training in mobile and game-based learning and to suggest future lines of research. For example, Montrieux and colleagues [10] stress that deeper changes to teaching and learning require schools to offer continuous training on teaching methodologies that allow teachers to make the most of mobile technology. In the same line, Ally, Grimus & Ebner [11] describe some projects around the world that are helping to prepare teachers for the mobile era, and some pilot projects using the technology. As mobile technologies emerge, teachers must keep up with the changes, so they must be trained in using mobile technology to teach, and students must be motivated to use it to learn. Therefore, both teacher training and professional development programs must be re-designed to train teachers to use emerging technologies, as teachers will become facilitators of learning and need training in this new role. The same authors stated that as the mobile technologies become more powerful and user-friendly, teachers must find creative ways to design learning materials for delivery on mobile devices, in appropriate ways to the subjects they teach.

Other authors [12] point out that implementing effective mobile learning programs requires adequate preparation of the teachers, through professional development and highlight that teachers should be encouraged to customize existing research-based mobile learning programs, minimizing the workload and time needed to innovate their practices. Anyway, it seems consensual that it is crucial to develop innovations around mobile learning pedagogies, considering that the fast development of mobile learning technology might have an impact on the ways that education is delivered, and teachers need to be aware of the potential of these emerging technologies.

More recently, in a study that involved 410 primary school teachers, Kamisli [13] found that teachers would like to use game-based learning approaches in their teaching practices, but they stated they felt incompetent and that they need training in the peculiarities of game-based learning approaches, application examples, course planning, course implementation, and evaluation processes. Thus, it is of key importance to identify teachers' skills and possible training needs in relation to game-based learning and to develop and implement teacher training programs, in order to spread the use of game-based learning approaches, as its proliferation depends on the extent to which teachers embrace them.

Being aware of these teacher training needs, stated in the literature, this contribution aims to provide an overview of the approaches and type of resources considered suited for teacher training, in the contexts of primary and/or secondary education, as well as the empirical results obtained in those training initiatives. For that, a literature review was conducted following the 2020 research procedure of the "Preferred Reporting Items for Systematic Reviews and Meta-Analyses" (PRISMA) [14]. It involved searching and screening publications indexed in ERIC until 2022 (included). The reviewed articles were related to teacher training focusing mobile or game-based learning, directed at primary and/or secondary teachers.

Besides this aim, the paper also includes an example of an accredited in-service teacher training program proposal, as an innovative training opportunity that revolves around mobile game-based learning with AR that was promoted under the scope of the EduCITY project. The EduCITY, <https://educity.web.ua.pt/>, is a project funded by the Foundation for Science and Technology (FCT), which intends to use outdoor learning strategies, by means of an interactive mobile AR app that supports outdoor activities in formal, non-formal and informal contexts, in the city. It previews the implementation of a set of teacher training courses and workshops to co-create games and other educational resources to be integrated in the app. The created games will be explored by teachers' classes and will be open access, so they could be useful to other teachers in terms of using them or be inspired through them to enhance their teaching practices.

Next sections include the method for the literature review, the results integrating the literature outputs and the teacher training program proposal, and finally some conclusions are put forward, considering that this is a work in progress paper.



## 2 METHOD

This literature review aims to provide an overview on teacher training about mobile and game-based learning for primary and secondary teachers. The 2020 PRISMA guidelines [14] were followed to ensure a rigorous evaluation of the existing literature, and to identify areas for future work.

The search strategy involved a search on the ERIC database, which is devoted to educational resources, including academic publications. The search was restricted to peer review works and the following search strings were used:

abstract:(("Teacher training") AND ("Mobile learning" OR "Game based learning")) OR  
 title:(("Teacher training") AND ("Mobile learning" OR "Game based learning")) OR  
 descriptor:(("Teacher training") AND ("Mobile learning" OR "Game based learning"))

No temporal limitations were imposed. The database returned 27 registers of peer reviewed publications. After screening the compliance with the inclusion and exclusion criteria, presented in Table 1, only three publications were included in this study analysis corpus.

*Table 1. Inclusion and exclusion criteria for registers retrieved with the search in ERIC.*

<i>Number</i>	<i>Criteria</i>	<i>Inclusion</i>	<i>Exclusion</i>	<i>Reasoning</i>
1	Focus of the study	Description/analysis of a preservice or in-service teacher training (even informal training) regarding the integration of mobile and/or game-based learning in teacher practice	Other focuses, such as surveys to identify teacher training needs	To exclusively include publications that contribute to answer this literature review research question
2	Study's participants	Pre-service or in-service teachers from primary and/or secondary education	Early childhood educators, higher education professors, adult education teachers, etc.	To exclusively include publications that contribute to answer this literature review research question
3	Language	English	Other languages	To exclusively include and analyse literature that is relevant for an international audience
4	Type of study	Empirical study	Literature review, proceedings, ...	To exclusively include and analyse primary sources of information
5	Peer review	Work submitted to peer review.	Work not submitted to peer review.	To exclusively include and analyse quality research

The data extracted from each study included the authors, year of publication, country, teacher trainees' level and subject, number of teacher trainees, training approaches, type of digital tools used in training, and training results. The data were organized and synthesized into a narrative summary and a comparative table, the Table 2, presented in the next section.

## 3 RESULTS

This section is organized in two sections: the first includes the literature review results and the second integrates the teacher training program proposal, as a way to provide an overview of the approaches and type of resources considered suitable for teacher training, in the contexts of primary and/or secondary education, as well as a specific proposal, as an example that can inspire teachers in their practices innovation.

### 3.1 Literature review results

Only three studies met the inclusion criteria: [15], [16], and [17].

Charlier and Fraine [15] conducted a study on game-based learning in teacher education. The study investigated the design, implementation and evaluation of two courses on digital game-based learning developed for the pre-service teacher training programme in health education in Flanders: one was developed as a workshop (implemented in two editions) and the other as a curricular unit in a master's course. The study highlights the importance of incorporating game-based learning in teacher education to support the integration of technology into the classroom.

Kilickaya [16] conducted a study on digital materials design in computer-assisted language learning. The study focused on two Turkish teachers of English as they created digital materials for their language classes. The study found that the teachers used a variety of multimedia resources, including images, audio, and video, to design their materials. The study highlights the importance of considering the design of digital materials in computer-assisted language learning, as well as the role of teachers in the role of creators of these materials.

Mettis and Våljataga [17] conducted a study on designing hybrid learning experiences for outdoor hybrid learning spaces. The study used a participatory design approach, involving teachers, students, and educational experts in the design process. The study highlights the importance of designing learning experiences that are situated in the real world and supported by technology.

Table 2 presents a synthesis of the studies participants, training approaches, tools and results.

*Table 2. Synthesis of the included studies.*

<b>Research paper</b>	<b>Trainees' profile</b>	<b>Number of trainees</b>	<b>Training approaches</b>	<b>Digital tools</b>	<b>Training main results</b>
Charlier & Fraine (2012) [15]	Future teachers with (bio)medical, sports and science background	58 in two workshop editions + 14 in a master course	<p>Workshops:</p> <ul style="list-style-type: none"> <li>- two seminars with practical &amp; theoretical background on game-based learning</li> <li>- manual on how to use software to make a game</li> <li>- group design and test of a learning game</li> <li>- presentation and discussion;</li> </ul> <p>One-semester course:</p> <ul style="list-style-type: none"> <li>- theoretical background on game-based learning</li> <li>- manual on how to use software to make a game</li> <li>- group research on game-based learning in secondary school: <ul style="list-style-type: none"> <li>▪ literature study</li> <li>▪ formulation of research questions</li> <li>▪ game development and investigation, including test with a class of students</li> <li>▪ paper</li> <li>▪ presentation to peers and instructors</li> </ul> </li> </ul>	Previous existing free software for game development: Excel, Hot Potatoes, Jclick, GameMaker	<ul style="list-style-type: none"> <li>- Trainees felt encouraged to use game-based learning in their future teaching, particularly for learning evaluation</li> <li>- acknowledgment of advantages (e.g., games offer a secure and contextual environment) and of disadvantages (e.g., effects on learners' health)</li> <li>- the training supported the development of problem-solving abilities and independent learning</li> <li>- the course trainees engaged their supervising teachers into using games in their classrooms during their research project</li> </ul>

<i>Research paper</i>	<i>Trainees' profile</i>	<i>Number of trainees</i>	<i>Training approaches</i>	<i>Digital tools</i>	<i>Training main results</i>
Kılıçkaya (2019) [16]	English teachers, 8 <sup>th</sup> grade	2	<ul style="list-style-type: none"> <li>- Seminar on benefits of using technology in the classroom</li> <li>- 15h of workshops (in five weeks) of hands-on experiences and tutorials on creating digital materials and using them with students</li> </ul>	Previous existing free software: Edmodo, ESL video, Cartoon Story, Make Beliefs Comix, Kahoot, The teacher's pet, Reading worksheet generator	<ul style="list-style-type: none"> <li>- Positive attitudes towards technology integration in teaching practices</li> <li>- wiliness to create and use digital materials</li> <li>- acknowledgment of the relevance of making the digital materials interesting and efficient</li> <li>- acknowledgement of constraints (e.g., time of preparation)</li> </ul>
Mettis & Våljataga (2021) [17]	K-12 teachers from different subjects; motivated; experienced (worked more than 5 years); familiar with the technological tools; held positive attitudes toward integrating technology into learning scenarios	Not clear (group of 2–3 teachers from participating schools)	<ul style="list-style-type: none"> <li>- Meeting to provide context and technological know-how</li> <li>- test by teachers of a mini learning scenario provided by experts</li> <li>- group development of a hybrid learning scenario: framed in curriculum, interdisciplinary, aiming competences' development</li> <li>- meeting to analyze problems and challenges</li> <li>- test with students from 1st to 9th grade</li> </ul>	Tool developed by the authors: Avastusrada, a web-based tool for creating and playing location-based learning tracks	<ul style="list-style-type: none"> <li>- Teachers asked for technological support (not instructional or content related)</li> <li>- Mobile learning design is a challenging task for teachers</li> <li>- Teachers revealed difficulty in: <ul style="list-style-type: none"> <li>▪ the creation of learning scenarios for higher levels of cognitive processes</li> <li>▪ making use of the power of authentic learning contexts</li> <li>▪ providing interdisciplinary learning experiences</li> </ul> </li> <li>- Mobile learning design in outdoor settings seems easier in science subjects</li> </ul>

In sum, the analysis of the studies revealed that the three training approaches included: 1) familiarization with digital tools that can be mobilized in teaching practices, which can be made through seminars or even through making manuals and tutorials available to (future) teachers; 2) the development of mobile and/or game-based learning projects, such as e, e.g., educational games; and 3) testing the educational resources developed with students. In two studies the digital tools explored in training were previously existing software, and in the other case it was explored a web-based tool developed specifically to support mobile learning. Overall, the training results obtained in these studies were: 1) Trainees' positive perceptions towards the integration of mobile and/or game-based learning in their (future) teaching practice; 2) Trainees' acknowledgement of both advantages and constraints regarding these approaches; 3) Exploring mobile and/or game-based learning is a challenging task for (future) teachers, particularly when it comes to design meaningful learning experiences; and 4) Teacher training is needed since pre-service courses, to support teachers in designing and using innovative approaches in their classrooms, considering both pedagogical and technological issues regarding mobile and game-based learning.

### 3.2 Teacher training proposal

The scarcity of teacher training on mobile game-based learning with AR makes it relevant to propose and disseminate an example of a teacher training proposal. In this case, the teacher training program was designed under the scope of a funded project, the EduCITY, whose goal is to enhance sustainable cities through the creation of a disruptive smart learning environment, sustained by a mobile app with active location games based on challenges, with AR educational multimedia resources. These games are co-created by the school, academic and wider community, and comprise enjoyable and interdisciplinary challenges to be explored by any citizen while touring the city to promote education for sustainability in real contexts. Similar projects, as EduPARK, have shown high usability and educational value of this type of approaches [18], particularly when teachers tried to create questions that promote thinking at a high cognitive level [19].

Aiming to improve the quality of teaching, through the integration of mobile and game-based learning, this teacher training proposes the design and development of a game, and other interdisciplinary digital educational resources, on education for sustainability. Those resources can be integrated into apps, such as the EduCITY app. The quality and relevance of those produced resources is supported by their articulation with the National Curriculum; and their implementation and evaluation in educational contexts of trainee teachers.

The main purpose of this teacher training proposal is to motivate trainee teachers to make effective changes in their educational practices, with a view to improve student learning. To do so, the aims are to: i) Create a training environment that promotes innovation in teaching practices, through the effective use of strategies involving mobile devices, games and educational resources, in promoting learning in education for sustainability; ii) Work on curricular themes in which students often have learning difficulties, according to the perception of trainee teachers, which can be successfully addressed through mobile game-based learning; iii) Design and develop educational multimedia resources about education for sustainability, contextualized in real educational contexts, in order to be integrated into apps, such as the EduCITY app; iv) Evaluate and refine the developed resources; and v) Make the developed resources available to the community, openly and free of charge.

The teacher training proposal includes the discussion of the educational potential of mobile game-based learning and digital educational resources, aimed at education for sustainability. It is developed under the EduCITY project, as an example of innovation in educational practices at the level of mobile game-based learning, in an interdisciplinary way. The exploration of the game approach is made through contextualized questions that promote thinking at different cognitive levels and, finally, it uses a purposely developed web platform for creating and sharing games and their digital educational resources.

This program is planned to be developed under a socio-constructivist paradigm, where the trainee teachers assume an active role in their professional development and the trainers adopt a role of facilitators of teachers' professional development processes.

The training is directed at teachers from different subject areas, such as physical, chemical and natural sciences, geography, and history, to support the development of cross-subjects work, and it includes: i) An initial contextualization on mobile and game-based learning, ii) A mobile gaming experience, as if teachers were students, iii) Hands-on project of mobile game creation, including the development of educative multimedia resources; iv) Game testing with the trainees' students; and v) Game results' analysis and reflection. Finally, the game produced during the training is made openly available to be useful to other teachers and students, and hence, inspire others to adopt these innovative approaches.

The work methodologies of face-to-face sessions include several different activities, such as: i) Debate and systematization of the trainees' perspective; ii) Field trip to explore a game of the EduCITY app; iii) Guidance on how to use the EduCITY web platform to create a game, to give technological support; iv) Collaborative work, in small groups, for the design and development of interdisciplinary digital educational resources on sustainability education, to be integrated into apps, such as the EduCITY app; v) Presentation and discussion of group work, as well as of the results obtained with the implementation in teacher trainees' classes; vi) Exploration of platforms to openly share digital educational resources; and vii) Completion of individual questionnaires to gather teachers' perceptions about the training program.

The work methodologies of the teachers' autonomous work include several activities, such as: i) Document analysis; ii) Written group reflection, based on a guide; iii) Collaborative work in small groups; iv) Implementation and evaluation of the developed game and its digital educational resources; and v) Written individual reflection on the training experience within this training program, based on a guide.

The assessment of trainees is based on the assumptions on a mandatory attendance of an accredited face-to-face teacher training. The evaluation criteria are in accordance with the guidelines of the training entity, based on the following items: i) Commitment and participation in face-to-face sessions (20%); and ii) E-portfolio development (80%), which includes the group reflections; the game and other digital educational resources developed, the analysis of the results of the implementation with students, and individual reflection on the training experience. The classification is grounded on a scale of 1 to 10.

The authors expect to implement this teacher training program, contributing to train teachers in using mobile technology and game-based approaches in their practices, promoting teachers' professional development, in line with Ally and colleagues' (2014) recommendation.

## 4 CONCLUSIONS

This study is a first step to provide a state-of-the-art regarding teacher training on mobile and game-based learning to propose a teacher training program capable of promoting practices transformation.

In a first stage, a literature review following the PRISMA guidelines was conducted. The search for literature was made in ERIC, a repository of education resources, and only three peer reviewed publications met the inclusion criteria. The results reveal a lack of empirical studies reporting research on training approaches for primary and secondary teachers, particularly the training approaches, tools and obtained results. The main limitation of this study is the low number of studies that met the inclusion criteria, so future work must consider include other sources of scientific publication registers.

The literature review supported the proposal of a teacher training program in this area. To make this proposal, the authors resorted to the results of this work, as well as their previous experience in similar contexts [20]–[22]. The relevance of this teacher training proposal relies on: i) the need of teacher training on mobile and game-based learning regarding the peculiarities of these approaches in articulation with their practices, as identified in the literature [10]–[13]; ii) the need of supporting teachers in the technological aspects of these approaches, as pointed by Kılıçkaya [16] and Mettis and Våljataga [17]; and iii) the relevance of providing teacher with practical examples of mobile and game-based approaches, as a model for the aimed innovative practices, in line with Mettis and Våljataga [17].

Future work involves the study of the implementation of this teacher training program to collect and analyze the results that can be obtained with this proposal in what concerns the educational resources produced, the teachers' perspectives on its impact on their professional development, and the training contribution for the innovation of teachers' practices. Future lines of research should include the efficacy of different teaching approaches in teacher training, teachers' adoption of mobile and game-based approaches after training in these topics, and the quality of mobile and game-based learning approaches developed by teachers with different training experiences on these topics.

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