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Educational Games for Mobile Applications: A Systematic Literature Mapping

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Abstract: The increasing popularity of mobile devices and advancements in digital gaming have stimulated the development of educational solutions that combine entertainment and learning. As part of Mobile Learning (m-learning) and Game-Based Learning (GBL) approaches, mobile educational games have been shown to promote motivation, engagement, and autonomy in the teaching process. This article presents a Systematic Literature Mapping (SLM) analysis of 176 studies published between 2019 and 2024 in the Scopus, Web of Science and IEEE Xplore databases. The objective was to identify trends, technologies, methodologies, and evaluation strategies relating to the development and use of educational games in mobile applications. The SLM protocol comprised three stages: planning, execution, and reporting. The results reveal the diversity of approaches and technologies adopted, including game engines, augmented reality, and native languages, as well as the application of various methodologies and gamification elements. There was also a growing emphasis on personalization and user-centered design. However, challenges such as a lack of standardization, limited empirical validation, and accessibility and infrastructure barriers persist. The SLM highlights the potential of mobile games in developing cognitive and socio-emotional skills and emphasizes the need for future studies to improve evaluation models and the personalization and application of these resources in different educational contexts.

Keywords: Systematic Literature Mapping, Educational Games, Mobile Applications

1 Introduction

Mobile technology offers users many advantages, including portability, touch-sensitive operating systems and applications, connectivity in different spaces and times, and stimulation of social interaction. The worldwide phenomenon of the advancement of mobile devices and educational apps [Bano *et al.*, 2018] is attracting great interest among researchers, including those in the field of education [Mou and Cohen, 2014].

The global phenomenon of the advancement of mobile devices and educational applications is accompanied by the exploration of other technologies, such as computer simulation and intelligent cloud-based platforms. These technologies aim to facilitate open learning models and revolutionize educational practices [Papadakis *et al.*, 2022]. In education, mobile technology allows students to participate in social learning contexts, creating favorable situations for collaborative learning. Mobile learning (M-learning), which can occur at any time and in any place [Sandberg *et al.*, 2011], requires methods that increase student motivation and engagement [Sandberg *et al.*, 2011]. One such method is the gamification of teaching, which is achieved mainly through the use of serious games.

Serious games are developed for purposes beyond entertainment [Dresch *et al.*, 2014], as they seek to engage users in playful activities with educational value [Gaggi *et al.*, 2017]. Their main objective is to promote learning in an engaging way. When associated with mobile devices, they result in educational mobile games that allow users to play in different real-world contexts at any time [Sánchez and Olivares, 2011]. To achieve this, it is essential that technology facilitates communication and interaction by offering collaborative and adaptive learning resources.

In recent years, mobile learning has attracted increasing interest as technological advances and multimedia have encouraged greater user involvement in the teaching and learning process [Laine *et al.*, 2022; Azlan and Junaini, 2023; Syafei and Suharjito, 2023; Papadakis *et al.*, 2020]. Numerous studies demonstrate that the interactive and playful features of mobile applications enhance motivation, making learning more dynamic and less confined to conventional teaching methods [Marcial *et al.*, 2022; Nuanmeesri, 2021]. The convergence of technological resources and pedagogical strategies improves the potential of mobile devices in various fields, promoting active participation and contextualized learning. In higher education, for example, gamified applications such as LabMorfoQuiz have been developed to support health students in learning complex subjects such as anatomy and physiology, demonstrating the relevance of this approach in formal academic contexts [Matos *et al.*, 2019].

Despite its advantages, there are several obstacles to the practical implementation of mobile learning. The most notable are a lack of financial resources, outdated educational policies, and inadequate teacher training. Teachers often resist changing their approach, parents distrust the prolonged use of mobile devices, and many institutions have inadequate infrastructure [Crompton *et al.*, 2017]. For mobile learning to reach its potential, governments, teachers, students, and society in general must be involved and willing to adapt.

In the 21st century, one of the main challenges in education is to maintain the interest and engagement of students who are increasingly connected to mobile devices [Kuznekoff *et al.*, 2015]. It is also important to develop higher-order cognitive skills such as problem solving and critical thinking [Arum and Roksa, 2011]. Mobile learning is an innovative approach [Shao and Liu, 2021], since it facilitates understanding of content and favors communication, creativity, and development of complex cognitive skills. Combining mobile learning with serious games creates dynamic, immersive, and contextualized educational environments. Despite the growing number of studies on the use of digital games in mobile learning, there are still few systematic reviews and mappings that consolidate the existing knowledge.

To fill this gap, this article aims to systematically investigate studies that deal with the development, application, and evaluation of mobile educational games, seeking to understand how these solutions have been designed and which analysis methods are most effective in measuring the impact on the teaching-learning process. For the purposes of this review, the term 'educational mobile app game' refers to complete mobile digital games developed primarily for educational purposes, as well as mobile educational apps that incorporate game elements and mechanics as the main pedagogical strategy to promote teaching and learning. To this end, the Systematic Literature Mapping (SLM) protocol proposed by Kitchenham and Charters [2007] was followed, covering the planning, execution, and reporting phases. During the planning phase, the objectives, research questions, search strategies, and study selection criteria were defined. In the execution phase, searches were conducted in relevant databases and the set of studies was refined using the inclusion and exclusion criteria. Finally, the report presents an analysis of the literature findings, discussing the quantitative and qualitative aspects that help to provide an in-depth understanding of the topic under investigation.

The results of this SLM are expected to benefit both the academic community and teachers and developers by offering an updated overview of the technologies, methodologies, and strategies employed in the design of mobile educational games. Furthermore, the study aims to highlight good practice, identify gaps, and suggest avenues for future research to promote the effective use of playful solutions as learning tools in line with contemporary societal demands.

In this context, in addition to the motivation arising from the literature, there is also a personal motivation for conducting this SLM. This motivation stems from a previous project [Sales and Oliveira, 2023], in which an educational application was developed to disseminate information about quilombola culture. While this application fulfilled its informative role, it was felt that it could be made more playful and interactive to foster greater user engagement and immersion. It is worth noting that the importance of using serious games for the preservation and teaching of Brazil's vast culture is also a topic of interest for other national researchers, who have explored the development and evaluation of prototypes for this purpose [Pereira *et al.*, 2023].

Based on this experience, interest in systematically researching the approaches and resources adopted in mobile educational games emerged. Thus, in addition to mapping trends in the literature, this SLM is also based on a personal goal: to gather support for the future development of an educational game focusing on cultural elements, such as quilombola culture, which integrates game mechanics and appropriate technologies and methodologies that facilitate development and improve user engagement.

This article is structured as follows: Section 2 presents the theoretical framework on mobile educational games, Section 3 describes some related works, Section 4 details the methodology used, Section 5 presents the results obtained, Section 6 discusses the lessons learned from this research, Section 7 discusses the threats to validity, and, finally, Section 9 presents the conclusions of this study.

2 Mobile Educational Games

Modern society is becoming increasingly connected, significantly changing the way information is shared and people relate to each other [Lévy, 2010]. This technological advance has opened up new possibilities for education, driven by the widespread use of smartphones and tablets. M-learning, which involves using mobile devices in the teaching and learning process, provides access to educational materials and resources almost anywhere and at any time [Ally, 2009]. Several applications have been created to assist in different knowledge areas [Yahuarcani *et al.*, 2021; Din and Ramli, 2023; Yadav and Oyelere, 2021; Pereira *et al.*, 2023], some of which focus on social inclusion, such as games for teaching Brazilian Sign Language (Libras) that aim to reduce communication barriers [Furquim *et al.*, 2025].

Mobile learning can be understood as electronic learning mediated by computers, laptops, mobile phones, audio players, and e-book readers [Hamidi and Chavoshi, 2018]. It also favors collaborative learning by enabling the exchange of ideas via the internet and various technological resources, thus overcoming the limitations of space and time [Gikas and Grant, 2013]. Additionally, this model brings school content closer to students' daily lives, serving as a bridge between formal and informal learning [Shao and Liu, 2021].

In this scenario, digital games have emerged as an effective strategy for promoting engagement and motivation. When used for a purpose that goes beyond mere entertainment, they are widely referred to in literature as 'serious games' [Michael and Chen, 2005]. Within this broad category, educational games stand out as a subset whose primary objective is specifically pedagogical. They use mechanics and narratives to facilitate the construction of knowledge and the development of skills [Dondi and Moretti, 2007]. This work focuses on the latter category, using the term 'mobile educational game' to refer to games designed for teaching and learning on mobile devices. Over a decade ago, Savi and Ulbricht [2008] drew attention to the interest shown by children, young people, and adults in this type of resource, given games' ability to captivate and engage users. According to Carvalho [2005], these games can be analyzed using criteria such as theme, duration, device used, number of players, opponent, and type of access. Furthermore, Silva *et al.* [2009] identify three universes of representation in games: the real (physical elements), the virtual (based on bits) and the imaginary (player subjectivity).

One of the main advantages of digital games is that they enable simultaneous information processing, favoring more interactive and non-linear learning [Prensky, 2001]. Gee [2003] also highlights that these games allow for immediate feedback, critical reflection, exploratory learning, discovery, and role-playing — elements that promote cognitive and social development.

In view of this, Game-Based Learning (GBL) emerges as an innovative pedagogical approach. GBL is based on structured educational games that combine mechanics, narratives, and challenges to encourage active knowledge construction [Prensky, 2001]. The versatility of this approach is demonstrated by its application in various contexts. Internationally, for example, the case study of the serious game "ThimelEdu" demonstrates how an interactive 3D environment with gamification elements can be effective in teaching about cultural heritage (the ancient Greek theater) [Papadakis *et al*., 2020]. In the Brazilian context, this approach is also being explored for various purposes, from preserving Brazilian culture [Pereira *et al*., 2023] and promoting social inclusion through teaching Libras [Furquim *et al*., 2025], to supporting active learning methods in health sciences courses, where gamified applications aid the study of morphofunctional content [Matos *et al*., 2019]. Regardless of the context, this format increases students' interest, encouraging experimentation, critical thinking, collaboration, and creativity [Gee, 2003]. Another fundamental aspect is the ability to make mistakes without real consequences, which encourages persistence and the development of new strategies [Antonaci *et al*., 2019].

Ubiquitous learning also deserves to be highlighted, as it enables students to learn at any time and place, transcending the limitations of the traditional classroom and aligning the learning process more closely with everyday life [Saccol *et al*., 2011]. When associated with gamification elements such as challenges, rewards, and competition, ubiquitous learning becomes even more flexible and dynamic [Werbach and Hunter, 2012].

In short, by combining technological innovation, interactivity, and applicability to everyday life, digital games and m-learning are becoming essential educational resources. As well as promoting a playful experience, these resources stimulate skills such as critical thinking, problem solving, and creativity, resulting in learning that is more dynamic, accessible, and inclusive.

3 Related Works

This section presents studies that have conducted systematic literature reviews or mappings in areas related to the focus of this study. This allows the present research to be contextualized and differentiated.

Afikah *et al*. [2022] conducted a Systematic Literature Review (SLR) focusing on the use of m-learning in Science teaching, emphasizing the development of higher-order thinking and communication skills. The study analyzed 30 works from 2012 to 2021 and found that smartphones were the most widely used device, with pedagogical approaches such as collaborative learning, research methodologies, and project-based learning being frequently employed. The results indicate improvements in student motivation and the development of complex skills, thereby reinforcing the relevance of mobile learning as a means of enhancing understanding of scientific content.

Ishaq *et al*. [2021] investigated how language learning can be supported by mobile devices and gamification elements through an SLR. Sixty-seven primary studies addressing gamification theories, frameworks, and practices in language learning applications were analyzed. The findings suggest that incorporating game features such as scores, levels, and rewards tends to boost learner engagement and motivation, leading to improved performance and fluency.

Hafidy *et al*. [2021] mapped gamified mobile applications that aim to improve driving behavior. Through systematic mapping, 220 such applications were identified in commercial repositories and academic databases. These were described in terms of their functionalities, the data they collect, their gamification mechanics, and their use of machine learning techniques to analyze driver behavior. The study showed that these applications can reduce risky behaviors on the road by providing real-time feedback, encouraging healthy competition, and setting safer, more sustainable driving goals.

Boncu *et al*. [2022] gathered evidence on the use of serious games and gamified mobile applications to encourage pro-environmental attitudes and behaviors. Based on an analysis of 29 studies, the authors concluded that immersion in playful narratives and the use of gamification strategies (e.g. rewards, challenges, and collaboration) contribute to increasing environmental awareness and the adoption of sustainable practices such as saving energy, reducing waste, and promoting community preservation actions.

Yomeldi *et al*. [2019] conducted a systematic literature review (SLR) on serious games for learning on mobile devices, emphasizing technological resources and aspects fundamental to improving educational performance. Four main characteristics that positively influence learning were identified: visualization, fun, immersion, and interactivity. Additionally, various technologies such as 3D virtual environments, web applications, and augmented reality are recommended for creating more engaging and effective gaming experiences.

Goundar *et al*. [2023] analyzed the use of mobile learning in early childhood education through an SLR, focusing on preschool children. By examining 54 studies, they found that educational games and apps focusing on language, literacy, arts, and colors were the most common. The results suggest that, with careful planning regarding usability and appropriate content for young children, the use of mobile technology in this age group can improve motivation, playful interaction, and interest in learni

In the context of specific domains, Laureano *et al*. [2020] mapped the use of games for teaching art education in Brazil through a systematic literature review (SLR) combined with netnographic research The systematic review analyzed works from 2015 to 2019 and concluded that the relationship between art education and games is still in its infancy in national academic production, indicating a fertile field for new research. The authors identified two main uses of games: studying cultural and historical themes contained in the narrative, and developing the game's own graphic materials with students.

Unlike the aforementioned studies, this study focuses on an SLM that encompasses mobile educational games for a wide range of teaching and learning purposes, rather than being restricted to a single domain, such as science, languages, or specific behaviors. The study also seeks to examine various approaches, including game elements and mechanics, methodologies, technologies, game evaluation methods, engagement, and game impact. Thus, this study aims to expand the scope of mobile educational games, providing support for the development of new solutions and pedagogical approaches tailored to diverse social and cultural con

4 Methodology

This work adopts the Systematic Literature Mapping methodology, which is a secondary study that integrates and analyses the evidence from primary studies relevant to a specific research question Kitchenham and Charters [2007]. SLM not only maps the collected studies, but also allows for an in-depth analysis of the relevant data. According to Kitchenham and Charters [2007], the systematic review/mapping process comprises three main phases: planning, execution, and reporting. The subsequent sections of this article detail the planning and execution stages of the review. This article fulfills the reporting phase, with the analyzed evidence presented in the Section 5.

4.1 Planning

In this initial stage, the SLM protocol was defined. This included formulating the research questions, defining the databases, constructing the search string, and establishing the inclusion and exclusion criteria for selecting studies.

4.1.1 Research Questions

The central objective of this SLM is to investigate the current situation and recent trends (of the last five years) in the development of mobile educational games, focusing on technologies, methodologies, application contexts, game elements used, and strategies for evaluating user engagement and learning. To achieve this, ten research questions were formulated to guide the search and data extraction process. These are presented in Table 1.

When outlining the research questions, it was recognized that there was a natural interrelationship between identifying game elements (RQ5) and analyzing engagement and motivation aspects (RQ6), since many playful elements aim to foster these states. However, it was decided that two distinct questions would allow for a more comprehensive and in-depth approach. The primary objective of RQ5 was to map the recurrence and variety of game elements currently in use. This survey can support the development of future games and enrich the literature by highlighting common practices. Conversely, RQ6 aimed to investigate the strategies and factors that promote engagement and motivation more broadly, including not only the presence of game elements, but also how they are combined and contextualized, as well as other relevant design approaches.

4.1.2 Databases, Search String and Inclusion (IC) and Exclusion (IC) Criteria

The search for studies was carried out in three internationally recognized databases: Scopus, Web of Science and IEEE Xplore. These databases were chosen due to the broad scope and relevance of their indexed content. This is in line with the objective of this SLM, which is to map the global research landscape on this topic without being restricted to a specific geographic or cultural context. The intention was to capture trends and practices from an international perspective, with the awareness that including databases with an exclusively Brazilian scope, such as Computer Brazilian Society (SBC) Open Lib (SOL), would result in a focus on a particular context, which was not the primary objective of this study. The availability of institutional access to these databases through the Coordination for the Improvement of Higher Education Personnel (CAPES) platform was also a practical factor in the selection process.

To cover different languages (Portuguese and English) and ensure relevant results, the following search strings were defined:

Portuguese: (”Aplicativo*” OR ”App*” OR ”Sistema*” OR ”Software*” OR ”Programa*” OR ”Ferramenta*” OR ”Aplicaç*”) AND (”Móve*” OR ”Digita*” OR ”Mobile” OR ”Celular*” OR ”Smartphone*”) AND (”Jog*” OR ”Gam*”) AND (”Educa*” OR ”Ensin*” OR ”Aprendiza*” OR ”Pedag*”)

English: (”Application*” OR ”App*” OR ”System*” OR ”Software*” OR ”Program*” OR ”Tool*”) AND (”Mobile*” OR ”Digital” OR ”Cellphone*” OR ”Smartphone*”) AND (”Gam*”) AND (”Education*” OR ”Teaching” OR ”Learning” OR ”Pedag*”)

The following inclusion and exclusion criteria were established to select the primary studies, which are presented below.

Inclusion Criteria:

- IC1: Studies addressing educational mobile applications implementing digital games,
- IC2: Studies evaluating the use of the game.

Exclusion Criteria:

- EC1: Studies that are not available for full access,
- EC2: Studies that are not in English or Portuguese,
- EC3: Studies published more than five (5) years ago,
- EC4: Studies that are not full papers/articles.

These inclusion and exclusion criteria were defined to ensure the viability of the review and the relevance of the selected studies for mapping the recent scenario. IC1 (studies addressing educational mobile applications implementing digital games) and IC2 (studies evaluating the use of the game) ensure that the selected studies focus on mobile educational games and have been evaluated. Regarding the exclusion criteria, EC1 (studies not available for full access)

Table 1. Research Questions

Research Questions (RQ)	**Motivation**
RQ1. What technologies are being used in the development of mobile educational games?	Identify the current tools and platforms for developing these games.
RQ2. What methodologies are being adopted to build mobile educational games?	Understand the development processes and approaches used to create these games.
RQ3. What is the application context of mobile educational games?	Know the environments and situations in which these games are used for educational purposes.
RQ4. What approaches are adopted to improve human-computer interaction in mobile educational games?	Investigate strategies to optimize the user experience and usability of games.
RQ5. What game elements are used in educational mobile applications?	Provide an overview of current design trends in mobile educational games by identifying the most frequently used game elements in the selected studies. This will support future developments and research in this area.
RQ6. What is the aspect related to user engagement and motivation in mobile educational games?	Analyze the various factors and strategies employed to promote user engagement and motivation.
RQ7. Who are the target audiences for mobile educational games in terms of age, skill level and special needs?	Investigate the target audiences of mobile educational games in order to optimize game design and content adaptation, ensuring effective and personalized learning outcomes for different age groups, skill levels, and specific needs.
RQ8. What is the impact of educational games on the teaching and learning process on mobile devices?	Evaluate the effectiveness of these games as learning tools and their effect on educational outcomes.
RQ9. How is the evaluation of these mobile educational games being carried out?	Understand the methods and instruments used to measure the quality and impact of games.
RQ10. What are the most commonly used game mechanics in educational mobile applications?	Identify the most popular and potentially effective types of game mechanics in the mobile educational context.

is essential to enable full reading and analysis of the content of the studies. EC2 (studies not written in English or Portuguese) was adopted on the basis that English is the predominant language for disseminating international scientific research in technology and education, providing access to a vast global body of literature. Inclusion of Portuguese studies, in turn, aimed to cover relevant scientific production in the Brazilian context, which is of particular interest to the authors and the intended audience of this study. EC3 (studies published more than five years ago) focuses the analysis on the most recent trends and current developments in educational games for mobile applications. This field is characterized by rapid technological, pedagogical, and design evolution, meaning that the last five years are representative of current practices and innovations. While it is recognized that such a timeframe may result in the exclusion of previously published seminal studies, the intention of this SLM is to provide an up-to-date overview, as outlined in the study's objectives. EC4 (studies that are not full papers/articles) aimed to ensure that only works with sufficiently detailed methodology and results were considered, excluding abstracts or conference papers of fewer than four pages.

4.2 Execution

The SLM was executed in sequential steps to ensure the identification of related studies. Firstly, the SLM protocol was formally defined to establish guidelines for all subsequent phases. This protocol was presented in Subsection 4.1.

The first concrete action of the execution phase was the initial collection of studies from the Scopus, Web of Science and IEEE Xplore databases. This initial search was carried out using the defined search terms (string) and the exclusion criteria EC2 and EC3 were applied within the database search tool itself. This resulted in a total of 14,057 records. Applying these initial criteria aimed to refine the dataset, focusing on studies in the relevant languages and within the research's timeframe.

Next, to ensure the uniqueness of the considered studies, the collected studies were stored in the Parsifal tool. Although the initial plan was to use this tool, which is designed for conducting SLR or SLM, throughout the SLM, the large number of studies returned caused the system to slow down, making continued use unfeasible. However, Parsifal has a feature for removing duplicate works, and using this feature reduced the dataset to 7,613 studies.

After removing the duplicates in Parsifal, the list of 7,613 studies was exported to a Google spreadsheet. This platform was chosen for all subsequent SLM phases, as it offers greater flexibility and agility for study analysis and selection.

The next step was the pre-selection of studies. For this, we read the titles, keywords, and abstracts of the 7,613 studies that were identified. The main objective was to conduct an initial screening to exclude studies that clearly did not fit the SLM theme, or that did not meet the previously defined inclusion criteria even at this superficial level of analysis. This preliminary analysis resulted in the selection of 2,811 studies.

Subsequently, exclusion criterion EC1 was applied. Studies that could not be accessed in full were removed, since a full content analysis is essential for conducting SLM research. This reduced the number of studies to 2,014. Next, exclusion criterion EC4 was applied to ensure that only full papers/articles were considered. This resulted in a set of 1,862 studies.

The final study selection step involved applying the inclusion criteria to the 1,862 pre-selected studies. The main objective was to verify whether the studies met IC1 and IC2 criteria. After applying IC1, 263 studies remained. Applying the IC2 criterion subsequently resulted in the final selection of 176 studies that met all the established SLM criteria. The complete list of these 176 studies, containing the identifier (ID) assigned in this review, the original title, and the year of publication can be found in Table 5 in the Appendix. Therefore, to answer the research questions, the codes (PS – primary study) of the studies listed in this table will be used. This reveals that of the 263 studies addressing mobile educational games, 87 did not evaluate the effectiveness or use of the games, indicating a significant gap in the research area.

Following the final selection of the 176 studies, the data were carefully extracted and organized in a new spreadsheet. To facilitate monitoring and targeted analysis, the spreadsheet was structured so that each research question, as defined in the initial planning phase, had its own column. This organization meant that, when reading and analyzing the studies in detail, the relevant information needed to answer each SLM question could be systematically collected and recorded.

Figure 1 provides a flowchart summarizing the SLM execution process. The chart shows the number of studies identified in each database and the progressive reduction in the dataset after applying the inclusion and exclusion criteria throughout the combination, duplicate removal, preselection, and final selection phases.

The mapping execution process, summarized in Figure 1, was conducted throughout 2024. The initial database search, corresponding to Step 1, took place in April 2024. Step 2, involving combining the studies, removing duplicates and pre-selection, took place between May and June 2024. Step 3 occurred in July and August 2024 and involved applying IC1, IC2, EC1, and Ec4. After the final corpus of 176 studies was defined, the in-depth reading and analysis phase for data extraction and answering the research questions took place between September and December 2024.

4.3 Report

The final phase of this SLM will present the detailed results obtained from analyzing the 176 selected studies. This analysis will cover both quantitative and qualitative aspects, which will be presented in Section 5.

In terms of the quantitative scope, data will be presented on the frequency of the approaches identified in the studies, the chronology of publications over the last five years, and the main forums for disseminating research in this field. To illustrate scientific output, charts will highlight authors with the largest number of publications on the topic, as well as events (conferences, journals, etc.) with the highest concentration of relevant publications for this SLM. These charts will enable the identification of the main contributors and the most important communication channels in the field of research on mobile educational games.

Section 5 will also present detailed charts on other quantitative aspects identified in the analysis, such as the technologies most frequently used in the reviewed studies, the most common development methodologies, the predominant game mechanics, and the most widely explored application contexts.

Regarding the qualitative aspects, the analysis will provide a detailed description of the technologies, methodologies, game mechanics, and application contexts identified in the studies. This qualitative analysis will provide a detailed understanding of current approaches and trends in the development and research of educational mobile games, complementing the quantitative information presented in Section 5.

The detailed results of this SLM, including the aforementioned charts, will be presented in subsequent sections of the article, alongside the discussion. This will provide a comprehensive understanding of the impact of mobile educational games on the teaching and learning process.

5 Results

As mentioned in previous sections, this section presents the results of an analysis of 176 primary studies published between 2019 and 2024. These studies were extracted from the Scopus, Web of Science and IEEE Xplore databases.

Firstly, an overview of the selected studies will be presented. Then, the main results obtained from the data extraction will be discussed in detail, providing answers to the research questions defined during the planning phase of this systematic literature mapping.

5.1 General Information on the Selected Studies

This section presents and discusses some general results derived from the analysis of the 176 studies that comprise this systematic mapping exercise. The subsequent charts provide an overview of these studies, covering topics such as their distribution over time, their origin in search databases, the most common publication venues (journals and conferences), and the most prolific authors.

Figure 2 illustrates the variation in the number of studies published between 2019 and 2024. Two periods stand out as having the highest concentration of studies: 2020 and 2022. In 2020, 37 studies were identified (21.0%), and in 2022, 38 studies (21.6%), representing the highest proportions compared to the other analyzed years. 2023 also showed a significant volume, with 36 studies (20.5%). In 2019, 32 studies were collected (18.2%), while 2021 saw a slight decrease with 28 studies (15.9%). Finally, by the time of the analysis, only five studies had been presented in 2024 (2.8%).

This temporal distribution suggests a considerable increase in research on mobile educational games between 2019 and 2022, which may have been influenced by the expansion of remote teaching methods and the growing popularity of hybrid learning. While 2021 saw fewer studies, the general trend indicates increasing attention to the topic in recent years, as evidenced by the continuation of research in 2023 and the initial studies in 2024.

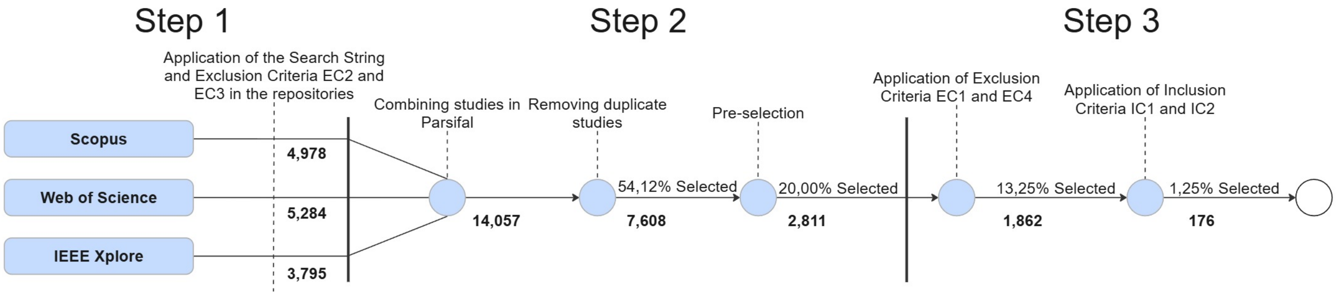

Figure 1. SLM Execution Flowchart.

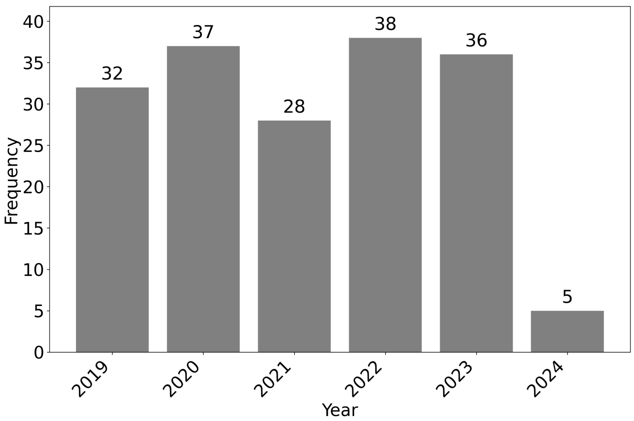

Figure 2. Studies by Year.

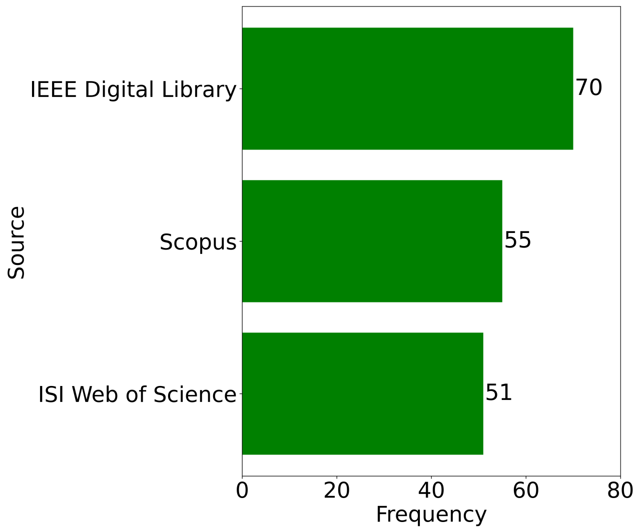

Figure 3. Distribution of Studies in Databases.

Figure 3 shows the number of studies located in each of the search databases used: IEEE Digital Library, Scopus, and ISI Web of Science. The IEEE Digital Library contains the largest number of selected studies, with a total of 70. Second place goes to the Scopus database with 55 studies, followed by the ISI Web of Science with 51.

IEEE's dominance can be attributed, in part, to the nature of the topic, given that the development of mobile educational games often involves technological aspects such as game engines, frameworks, and computational solutions. IEEE is recognized as a globally relevant database for Engineering and Computing research. However, Scopus and the ISI Web of Science databases are also essential for covering the topic's multidisciplinary nature, including studies from related areas such as education, health, and human sciences.

Figure 4 shows a chart of the most frequently occurring main publication forums (conferences and journals) among the 176 selected studies. JMIR Serious Games is the leader with ten studies, followed by the International Journal of Interactive Mobile Technologies with seven. Both journals are recognized for their dedication to research integrating the perspectives of health, technology, and interactivity.

Other journals and conferences include the Journal of Chemical Education, the Journal of Physics: Conference Series and the IOP Conference Series (focused on science and engineering), each of which has published four studies. Relevant events in engineering, computing, and education include the IEEE World Conference on Engineering Education (EDUNINE), the IEEE Global Engineering Education Conference (EDUCON), and the IEEE International Conference on Serious Games and Applications for Health (SeGAH), with three studies each. The consistent presence of IEEE-linked forums reinforces the importance and relevance of mobile educational games within the Engineering, Computing, and Educational Technologies community.

Finally, Figure 5 shows a chart of the researchers who contributed most to the selected studies in this SLM. The following stand out in first place, with six studies each: Llaja, Lelis Antony Saravia; Yahutacani, Isaac Ocampo; and Satalaya, Angela Milagros Nuñez. It is important to emphasize that these three researchers collaborated on the same six studies. Next, with five studies, is Cruzado, Javier Arturo Gamboa. Later, three authors appear with three studies each: Pezo, Alejandro Reátegui; Lagos, Kay Dernise Jeri; and Gómez, Edgar Gutiérrez. It is also worth noting that these four authors participated in the studies of the first three authors.

This concentration of studies among a select group of authors suggests that a significant proportion of research into mobile educational games may be conducted by specific groups or research centers, possibly involving ongoing projects over several years. This also indicates the existence of groups of researchers specializing in the subject, which can foster relevant advances and collaborations in the area.

A general analysis of the data allows us to draw the following conclusions:

- The increase in the number of studies in recent years, especially in 2020 and 2022, reflects the growing consolidation of research integrating mobile technology, pedagogical methodologies, and playful engagement elements,

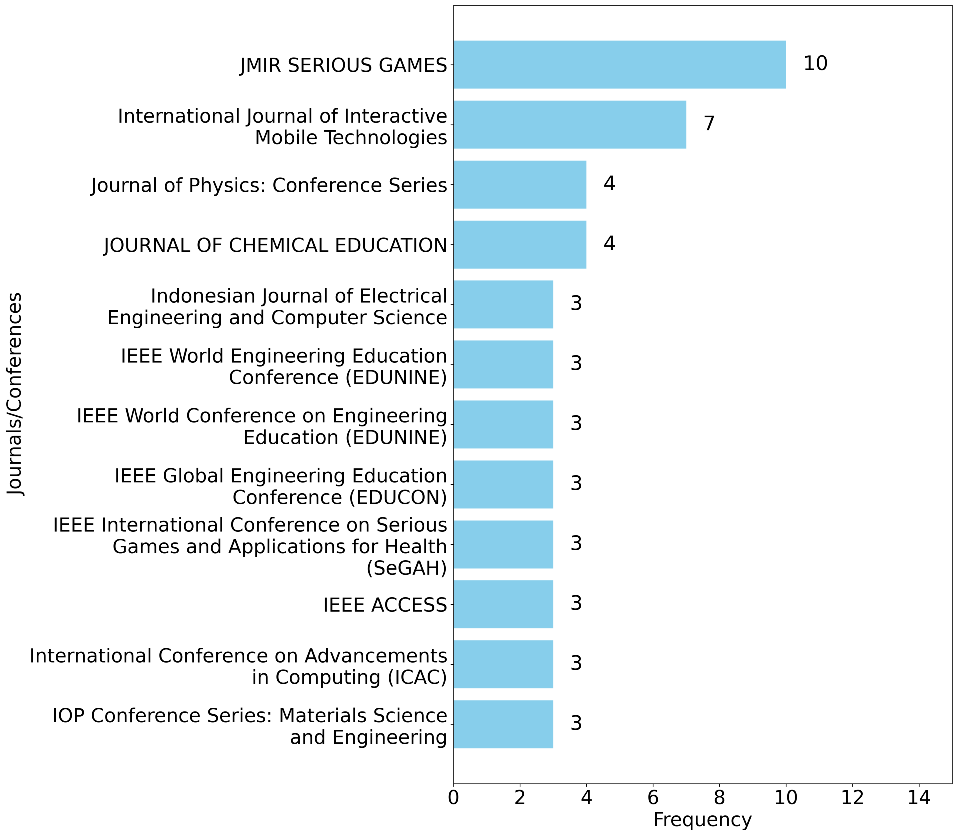

Figure 4. Top 12 Journals and Conferences.

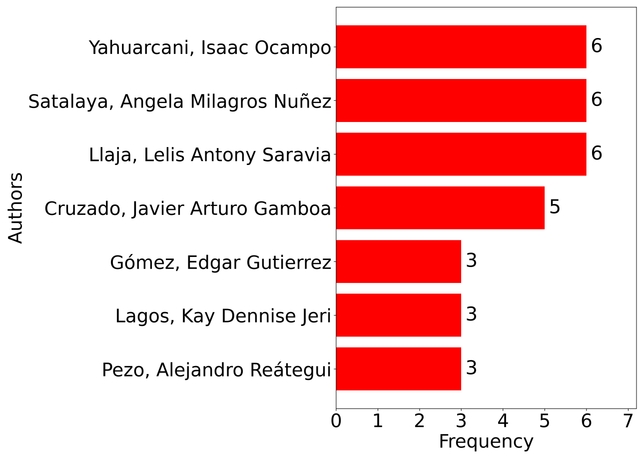

Figure 5. Top 7 Studies Authors.

- The predominance of studies indexed in the IEEE Digital Library highlights the importance of events and journals related to computing and engineering in disseminating research on mobile educational games,
- The most prominent forums, such as JMIR Serious Games and iJIM, demonstrate the scientific community's interest in technological aspects as well as health, inclusion, and interdisciplinary learning,
- The group of authors with the largest number of studies indicates the formation of consolidated lines of research that can guide future studies by sharing results, methodologies, and opportunities for innovation.

This provides an initial overview of the distribution of studies over the last few years, the predominant dissemination channels, and the authors who have contributed most to advancing research in this area. The subsequent section will provide detailed qualitative analyses of the technologies, methodological approaches, game mechanics, and other factors investigated in the selected studies.

5.2 (RQ1) What technologies are being used in the development of mobile educational games?

This research question aims to identify the most commonly used technologies for developing mobile educational games and the platforms on which these games are developed. Analyzing the selected studies allowed us to identify the variety of tools, programming languages, and game engines used to develop these applications.

As shown in Figure 6, the most frequently used technology is Unity, present in 35.23% of the selected studies (62 studies). Unity is a cross-platform game engine that supports Android and iOS, as well as other platforms, which explains its widespread adoption. Its ability to integrate technologies such as Vuforia for augmented reality together with the C# language — used in 11.36% of the studies (20 works) — makes Unity a versatile choice for the development of interactive and immersive mobile educational games and applications.

In addition to Unity, other technologies also stand out, such as:

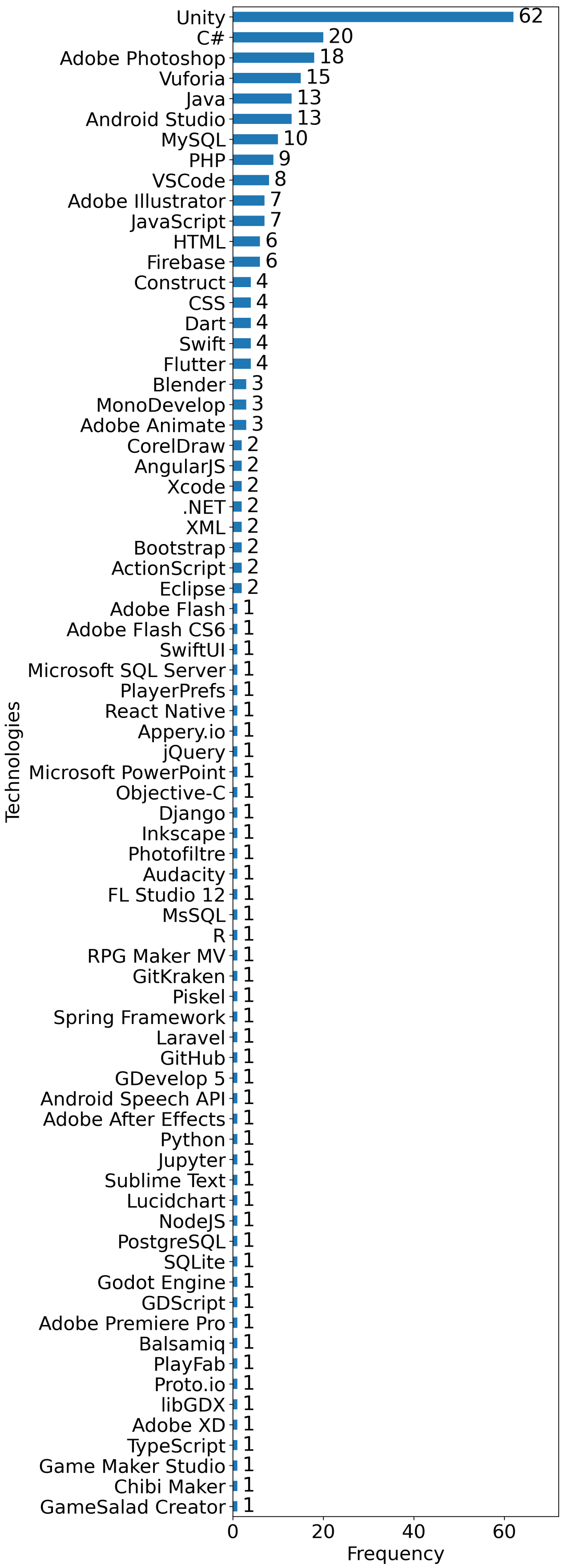

Figure 6. Technologies most used in selected studies.

- Android Studio, which is an official integrated development environment (IDE) for the Android platform that allows the creation of native applications in Java or Kotlin. It was used in 7.39% of the studies (13 works), reflecting the importance of reaching a wide audience through development for the Android platform,
- Vuforia, an augmented reality platform, was used in 8.52% of the studies (15 works). Vuforia is often used in conjunction with Unity to develop applications that integrate virtual elements into the real world, creating immersive experiences that enrich learning,
- Graphic design tools such as Adobe Photoshop and Adobe Illustrator were widely mentioned in 10.23% (18 works) and 3.98% (7 works) studies, respectively. These tools highlight the importance of attractive visual resources in mobile educational games, contributing to user motivation and engagement,
- MySQL was used in 5.68% of the studies (10 works) for database management, essential for storing and managing data for mobile educational games and applications. It is often used in conjunction with Unity and Android Studio, highlighting its importance in projects that require robust data storage,
- PHP is present in 5.11% of the studies (9 works), and is mainly used for web development. It is a programming language that facilitates the creation of robust backend functionalities when combined with other technologies, providing a solid foundation for interactive applications,
- Visual Studio Code (VSCode) was used in 4.55% of the studies (8 works). VSCode is a lightweight and versatile source code editor, adopted for developing scripts and interactive web applications, facilitating integration with other technologies used in the projects,
- JavaScript is also present in 4.55% of the studies (8 works), being used to create dynamic interfaces and frontend functionalities, essential for interactivity and user experience in games and educational applications,
- Firebase was used in 3.98% of the studies (7 works). Firebase is a backend development platform that offers services such as authentication, real-time database and hosting, essential for online functionalities and data storage in mobile educational games.
- HTML and CSS were used in 3.41% (6 works) and 2.84% (5 works) studies, respectively, which helps create accessible and aesthetically pleasing web interfaces, improving both online presence and usability,
- The Dart programming language in conjunction with the Flutter framework were used in 2.27% of the studies (4 works), offering a robust alternative for the rapid development of multiplatform applications. Flutter enabled the creation of highly responsive and customizable user interfaces, essential for engaging young users in dynamic learning environments,
- Swift was used in 2.27% of the studies (4 works), for development on iOS devices, ensuring native and optimized interfaces for this platform, essential for providing a fluid and integrated user experience,
- Adobe Animate is present in 1.70% of the studies (3 works), used to create interactive animations that increase student engagement in educational applications.

Unity is often used alongside the C# programming language. It stands out for enabling the creation of 2D and 3D games with advanced graphics, realistic physics and cross-platform support, which facilitates development for Android and iOS systems. For example, study PS03 used Unity and C# to create an educational game with interactive 3D features.

Several studies, such as PS28, PS38, PS96, PS141, PS143, PS160, and PS170, also note the integration of Unity with Vuforia, enabling the development of augmented reality applications that enrich the educational experience. Additionally, graphic design tools such as Adobe Photoshop and Adobe Illustrator are frequently cited (PS03, PS45, PS56, PS85, PS123, and PS152) for developing visual resources.

In native Android development, Java and Android Studio are often used due to their ability to create high-performance native applications with integration of platform-specific features. PS35 used Android Studio and Java to develop a Portuguese learning app for Chinese speakers, while PS61 created an educational chemistry game about colloids using the same technologies. Using Android Studio enables developers to utilize official tools and advanced features to optimize the performance of mobile applications.

PHP and JavaScript, in conjunction with the MySQL database, are used to develop the backend functionality and data management systems of educational applications. For example, PS13 developed a mobile application to help first-year students find their way around a university library. They used Unity for the frontend and PHP with MySQL for the backend, which allowed them to manage information and user interactions efficiently. VSCode is often cited as the preferred integrated development environment (IDE) for languages such as C#, JavaScript, and PHP due to its flexibility and extension support.

Firebase is a popular choice for studies requiring backend functionality such as authentication, real-time data storage and hosting. In PS144, Firebase was used to store player data and manage online functionality in a serious game called OOP Codes, facilitating the implementation of features such as rankings and usage statistics. Similarly, in PS164, Firebase was used for data management and ranking functionality in an application designed to improve communication between doctors and patients.

Web technologies such as HTML, CSS, and JavaScript are essential for developing web and hybrid applications, providing accessibility and universality. PS23 implemented a serious game to help users self-regulate their heart rate. These technologies were used in conjunction with the Titanium SDK to generate cross-platform applications for Android and iOS. Using these languages enables applications to run on different devices without requiring separate development for each platform.

The Dart programming language and the Flutter framework have become popular for developing cross-platform mobile applications. PS71, for instance, developed a game with Flutter and Dart, creating an experience that runs on both Android and iOS devices. Flutter enables the fast and efficient development of engaging user interfaces thanks to its customizable widget system and hot reload feature, which speeds up the development process.

For native iOS development, the main tools are Swift and Xcode. PS01 used Xcode and Swift to develop mini-games for iOS devices that focus on developing fine motor movements in children. The choice of these tools is motivated by the need to optimize applications for the Apple ecosystem, ensuring performance and compatibility.

Adobe Animate is used for interactive animations and media-rich content. For example, in PS106 an interactive application was developed for children with Down's syndrome, combining mobile educational games with animated elements to improve cognitive capacity and image retention through visual associations. Adobe Animate enables the creation of animated content that can be incorporated into mobile and web applications to enhance the user experience.

These technologies have been widely adopted for several reasons, including ease of integration, availability of resources and documentation, and ability to meet the specific needs of educational projects. For example, Unity is valued for its versatility and support for advanced features such as augmented reality, particularly when used alongside Vuforia. Adobe Photoshop and Illustrator are essential tools for creating attractive visual interfaces, which are critical for engaging users in educational applications. Programming languages such as Java and C# are chosen for their robustness and performance, while frameworks such as Flutter offer modern solutions for cross-platform development.

In conclusion, the analysis of the studies shows that these technologies play a crucial role in the development of mobile educational games. Combining tools such as Unity, C#, Adobe Photoshop, Vuforia, Java, Android Studio, MySQL, PHP, VSCode, JavaScript, Adobe Illustrator, Firebase, HTML, CSS, Dart, Flutter, and Swift enables the creation of feature-rich, interactive applications tailored to diverse educational contexts. These technologies facilitate the development process and contribute to creating more engaging and effective learning experiences, thereby promoting positive educational outcomes.

Figure 7 shows the frequency with which the various platforms are used for developing mobile educational games.

As can be seen from the chart in Figure 7, the following can be observed:

- Android is the most targeted platform, with 43.75% of studies developing applications exclusively for this operating system. This reflects the widespread adoption of Android devices globally and the ease with which applications can be distributed through the Google Play Store. Of the studies that use both platforms, 109 (61.93%) use Android,
- iOS is mentioned in only 4.54% of the studies, indicating its more limited popularity. This limitation may stem from two factors: the lower market penetration of Apple devices and the fact that their target audience has less purchasing power, making costly iOS devices less accessible. However, when including the studies that use both platforms, 40 studies (22.72%) use iOS.

Eighteen point one eight percent (18.18%) of the studies target both platforms (Android and iOS), demonstrating a concern with serving users from different mobile ecosystems and maximizing accessibility.

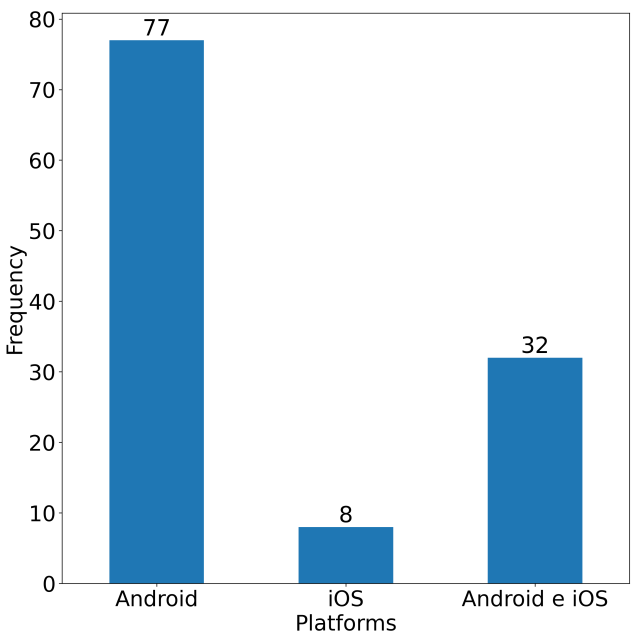

Figure 7. Most used platforms in selected studies.

The selection of technologies and platforms is often justified by the need to develop effective, interactive applications that can engage target audiences in various educational contexts. Unity's popularity and versatility as a development platform for mobile educational games is evident from its prevalence, offering advanced features and an active community that facilitates the sharing of resources and knowledge. Other technologies are chosen based on criteria such as ease of use, specific project requirements, and the skills of the development team.

In short, the variety of technologies and tools adopted reflects the complexity and multifaceted nature of educational projects. Strategically combining different platforms and tools enables the creation of innovative educational solutions tailored to the specific needs of each audience, promoting more dynamic and effective learning.

A critical analysis reveals a markedly strategic and mature technological ecosystem. For example, the consolidation of Unity as the main tool represents a significant advance for the field, as it democratizes access to sophisticated development resources and accelerates the research cycle. This allows more teams to create immersive experiences, such as augmented reality, more efficiently. Additionally, the predominant focus on the Android platform is a well-founded decision aimed at maximizing the impact and accessibility of educational solutions to reach the largest possible audience. However, this strategic specialization involves tradeoffs that deserve consideration. Although efficient, reliance on a single game engine can lead to standardization in technology and pedagogy, encouraging solutions that adapt well to the tool at the expense of innovative approaches that may require different technologies. Additionally, the lower expressiveness of the iOS ecosystem, while understandable from a market perspective, creates a gap in our understanding of how different user profiles interact with educational games. Therefore, the current situation is one of a field that has optimized its production to increase its scale and impact.

5.3 (RQ2) What methodologies are being adopted to build mobile educational games?

The second research question examines the various methodologies for developing mobile educational games, as detailed in the selected studies. Generally speaking, there is no single pattern; rather, each project adopts strategies that are aligned with its specific context, target audience, pedagogical content, and learning objectives. However, both classic software development methodologies (e.g. ADDIE — Analyze, Design, Develop, Implement, Evaluate; MDLC — Multimedia Development Life Cycle; Waterfall) and agile approaches (e.g. Scrum, Extreme Programming, RAD — Rapid Application Development) are evident. It is also noteworthy that some methodologies actively involve users (participatory design, user-centered design and player-centered design), while others are based on educational and motivational theories (Social Learning Theory, Protection Motivation Theory and Models of Planned Behavior). Some studies combine qualitative and quantitative methods in a mixed-research approach.

One of the most common models is ADDIE (PS33, PS59, PS61, PS62, PS76, PS105, PS110, PS140, PS173), in which the analysis, design, development, implementation, and evaluation stages structure the entire process. This methodology favors the integration of educational content, multimedia resources, and game mechanics to ensure that the final product is consistent with users' needs. In PS62, for instance, ADDIE was used to create a WAN technology teaching application for vocational schools, demonstrating the effectiveness of the resource. Similarly, PS61 applied the model to a colloid game, taking a systematic approach from initial conceptualization to usability testing.

MDLC also features prominently in PS02, PS04, and PS31. MDLC offers a clear roadmap for integrating complex content in an interactive format through stages such as conceptualization, design, material collection, assembly, testing, and distribution. For example, PS02 used MMCD (a variation of MDLC) to create the Vocab Library, an English vocabulary application which enables a structured view of content analysis, user experience design, and functionality testing.

Agile methodologies (Scrum, Extreme Programming, and Rapid Application Development) are employed in projects that require rapid delivery and continuous feedback. In PS20, development was based on player-centered design principles, combining user experience (UX) design with a focus on the user-player. In PS60, researchers conducted an expert assessment alongside prototyping to create a programmable logic controller (PLC) wiring tool. Scrum is used in PS21 for the Tic-Tac-Training game, involving frequent meetings, short sprints, and constant re-evaluation of the product. Extreme Programming was adopted in PS36 and PS86 to allow greater flexibility in adapting to needs that arise throughout the process, which is essential for projects dealing with accessibility, such as the Shipibo-Konibo language project in PS86.

User-centered design (UCD) and participatory design emphasize the importance of collaborating with experts, children, families, teachers, and therapists (PS05, PS24, PS28, PS41, and PS132). For example, PS24 used participatory design when developing a game for children with dyslexia, incorporating continuous feedback from the target audience. PS28 adopted a design-based research approach, conducting user testing in iterative cycles. Listening to stakeholders in these cases ensures that the game is relevant in terms of content, as well as being inclusive, motivating, and appropriate to the cognitive and emotional needs of learners.

Mixed research methodologies (both quantitative and qualitative) are employed when the aim is to assess not only whether a game is effective, but also how and why it is effective (PS13, PS68, and PS96, for example). For example, PS13 adopted an explanatory sequential design to understand the acceptance and use of a library guidance application. Similarly, PS68 involved developing a serious game about health claims and carrying out four analysis phases combining quantitative and qualitative methods, from initial design to impact assessment. PS96 also used mixed research to validate its findings when studying the effect of Augmented Reality on the prevention of COIVD-19.

In terms of theoretical basis, many studies rely on established theories to inform game development. For instance, PS05 combined the Delphi technique to validate asthma-related content with Growth Theory to develop the narrative. PS122 used Protection Motivation Theory and Social Learning Theory in 'Pets vs Onco' to align game mechanics with psychological factors that encourage treatment adherence. PS112 and PS171 emphasize the importance of motivational approaches by highlighting the player's interest cycle. PS41 and PS95 use gamification and self-regulation learning theories to ensure the game remains attractive and pedagogically effective.

Some studies employ action research and design-based research methodologies (PS28, PS119, PS133, and PS164). In these cases, observing in a real context enables continuous adjustments to be made to the application. One of the studies analyzed (PS133) applied the Design Science Research (DSR) methodology specifically to the development of a mobile app for memory training in older people. According to the authors, the choice of the DSR method occurred because it involved the creation of a physical artifact, not just a theoretical study. The methodology comprised six phases, with the first two focused on defining the problem and objectives of the proposed solution. The subsequent stages involved iterative cycles of development and continuous evaluation, allowing constant adaptations based on the feedback received. An additional phase of pilot testing and analysis of results was incorporated, highlighting the importance of direct user involvement. Thus, although DSR is traditionally associated with academic research, in this specific case, the authors explicitly reported its application as an agile and flexible methodology for the practical and iterative development of the educational game. PS164 combined health communication theories with iterative refinement methods, aiming to improve medical residents' ability to deal with diagnostic uncertainties.

Finally, some projects opt for their own development processes, aligned with specific frameworks or guidelines. In PS23, when creating the FitLab Game, an initial development phase of the application was followed by a pilot study analyzing whether cardiorespiratory biofeedback could be self-regulated by the participants. PS148 applied the Persuasive System Design Model to create a sex education app, while PS153 adopted user-centered design principles with iterative assessments guided by therapists to promote health and well-being.

In summary, the development of mobile educational games demonstrates significant diversity and methodological flexibility. Studies in this field combine pedagogical theories, active user participation, continuous evaluation cycles, and motivational theory to create final products that combine quality content, engagement, and learning effectiveness. This variety of approaches and models ensures that each project can be adapted to specific objectives and usage contexts, resulting in educational solutions that better align with the real needs of end users.

A central observation about the methodologies is that there is no single path; rather, there is a wide variety of approaches. This can be seen as a sign of the area's maturity, as it indicates that developers are choosing their methods consciously, considering the objectives of each game and its specific audience, rather than just following a ready-made formula. However, this flexibility requires very clear documentation from the researchers. When a study merely mentions that a method was used, but does not detail how it was adapted in practice, it becomes challenging for other researchers to learn from that experience or attempt to replicate it. Without this transparency in the report, the diversity of methods, which is a strength, risks hindering the construction of solid and shared knowledge in the field.

5.4 (RQ3) What is the application context of mobile educational games?

The aim of this research question is to identify the various contexts in which mobile educational games are being used, as revealed by the selected studies. The data analysis revealed a wide variety of application areas. As shown in Figure 8, the most frequently addressed context is language learning, present in 24.43% of the selected studies (43 works). This context involves using mobile educational games to facilitate language learning. The widespread adoption of this context can be attributed to the effectiveness of games in promoting vocabulary, grammar, and pronunciation practice in an playful and accessible way.

From the chart in Figure 8, we can see that the application contexts were categorized into 11 (eleven) main areas. Below, we present a brief description of each area:

- **Language Learning**, as previously mentioned, includes games that help in learning new languages, developing vocabulary and improving language skills,
- **Science Education** includes games that address scientific concepts in areas such as astronomy, chemistry and biology,
- **Computer Science and Technology Education** includes games that promote the teaching of programming, computing concepts, and technological skills,
- **Health Education** includes games that aim to educate on health topics, promote healthy habits, and manage medical conditions,

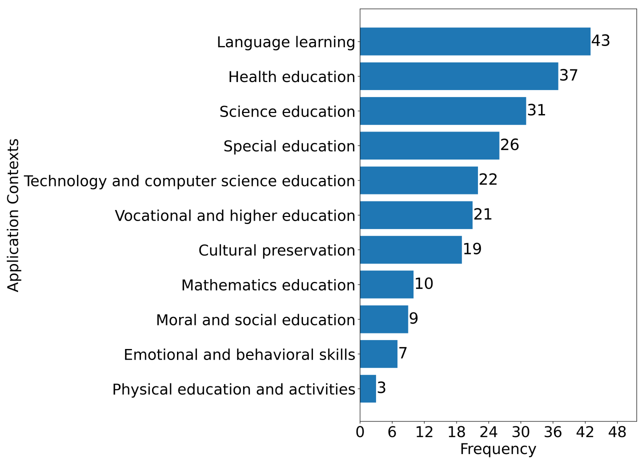

Figure 8. Frequency of Application Contexts in Selected Studies.

- **Special Education** includes games developed to support the learning of individuals with special needs, such as Attention Deficit Hyperactivity Disorder (ADHD), autism, and hearing impairment,
- **Mathematics Education** involves games that facilitate the learning of mathematical concepts and arithmetic skills,
- **Cultural Preservation** includes games that aim to preserve and promote cultural heritage, indigenous languages, and local traditions.
- **Vocational and Higher Education** includes games aimed at higher or professional level students, addressing specific topics in their study areas,
- **Moral and Social Education** includes games that promote moral values, ethics and social awareness,
- **Emotional and Behavioral Skills** includes games that help develop skills such as empathy, resilience, emotional regulation and conflict resolution,
- **Physical Education and Activities** includes games that promote the practice of physical activities and the learning of concepts related to bodily health,

Taking into account these 11 main areas, the quantification of studies by context, the corresponding percentage and the list of identifiers (PS) of each study associated with a specific context can be viewed in Table 2.

It is evident that mobile educational games have been utilized in a variety of contexts to meet the diverse educational needs of different populations. Language learning is the context in which they have been used most frequently, reflecting the demand for tools that help to develop language skills in an interactive way. Several applications have been developed to facilitate language learning using gamification techniques and emerging technologies. For instance, PS02 created a mobile app to help users learn English vocabulary, offering an interactive experience to aid word memorization. PS03 created a 3D board game to improve English vocabulary retention and fluency among high school students. PS35 applied gamification techniques to facilitate Portuguese learning for Chinese speakers.

PS81 developed the Pickstar game to help children with autism spectrum disorder learn vocabulary, maximizing engagement and independence. PS85 introduced the mobile EWORD game to help primary school children learn English words and increase their engagement and learning ability. PS93 created a virtual reality app to help students learn English, thereby increasing acceptance of technology and improving learning effectiveness. Additionally, PS107 introduced a gamification approach to learning complex morphology, focusing on Turkish as an exemplary language to benefit foreign language learners. PS126 developed the Kabisa App, a game-based learning tool for the Sundanese alphabet that promotes cultural preservation. PS142 introduced mobile apps to help dyslexic children learn reading and writing skills through interactive games. PS168 created a gamified app to improve English literacy among Year 1 pupils using interactive multimedia elements.

Another significant context is health education, where games are used to promote healthy habits, raise awareness of diseases, and support patients undergoing treatment. PS05 developed MIRACLE, a digital educational programme for children with asthma, to improve knowledge of asthma self-management and inhalation techniques. PS23 introduced a serious game to help users self-regulate their heart rate variability through cardiorespiratory biofeedback. PS74 developed the Barty serious game to combat childhood obesity by encouraging children to adopt healthy eating habits and engage in physical activity.

PS90 developed SAAFE, a serious game designed for and with young people who identify as African-American to promote healthy sexual behaviors. PS117 introduced Fooya!, a mobile game that promotes healthy behavioral changes in children by influencing their food choices. Additionally, PS122 developed the Pets vs. Onco game to motivate children with cancer to adhere to their treatment regimens by promoting daily self-care. PS165 created a serious game to educate people about behavior and traffic safety, with the aim of reducing accidents and promoting safe practices among road users.

The field of science education has been widely explored through games that facilitate an interactive and engaging understanding of complex scientific concepts. PS12 introduced PlanetarySystemGO, a gamified system for teaching astronomical concepts interactively. PS28 developed the EduPARK application to promote interactive learning in parks through practical, contextualized activities. PS55 created DivTCell, a gamified app designed to teach high school students about eukaryotic cell division. PS87 proposed Elemem, a game based on digital cards that teaches the periodic table and chemical elements in a relevant and contextualized way. PS141 investigated the motivational benefits and usability of an augmented reality game for learning anatomy, offering an immersive experience. Finally, PS170 developed ARCell, an augmented reality mobile game designed to help students learn about the structures of animal and plant cells.

Several studies in Special Education have focused on supporting individuals with special needs in their learning by developing adapted games. PS24 presented Mila-Learn, a game offering rhythmic exercises to improve the phonological and reading skills of children with dyslexia. PS70 developed smartphone games aimed at training working memory in children with autism spectrum disorder. PS79 created Dilud, a mobile app designed to enhance working memory in children with Attention Deficit Hyperactivity Disor-

Table 2. Application Context by Study

Application Context	Studies	Percentage
Language Learning	PS02, PS03, PS06, PS09, PS14, PS29, PS32, PS33, PS34, PS35, PS36, PS39, PS54, PS67, PS69, PS73, PS77, PS81, PS83, PS84, PS85, PS86, PS93, PS94, PS97, PS103, PS107, PS108, PS116, PS126, PS127, PS131, PS135, PS139, PS142, PS150, PS154, PS160, PS163, PS166, PS168, PS171, PS174.	24.43%
Health Education	PS05, PS16, PS20, PS23, PS43, PS45, PS48, PS50, PS56, PS58, PS65, PS66, PS68, PS71, PS74, PS90, PS92, PS96, PS98, PS100, PS101, PS109, PS114, PS117, PS122, PS133, PS138, PS145, PS147, PS148, PS153, PS158, PS161, PS164, PS165, PS169, PS172.	21.02%
Science Education	PS12, PS28, PS30, PS40, PS44, PS48, PS55, PS58, PS61, PS80, PS82, PS84, PS87, PS92, PS113, PS115, PS118, PS119, PS120, PS125, PS134, PS137, PS141, PS146, PS151, PS162, PS167, PS170, PS173, PS175, PS176.	17.61%
Special Education	PS01, PS10, PS17, PS24, PS25, PS27, PS29, PS32, PS39, PS42, PS50, PS70, PS75, PS78, PS79, PS81, PS91, PS103, PS104, PS106, PS121, PS124, PS131, PS132, PS139, PS142.	14.77%
Computer Science and Technology Education	PS15, PS22, PS30, PS37, PS38, PS47, PS51, PS52, PS57, PS60, PS62, PS63, PS105, PS112, PS125, PS136, PS140, PS144, PS149, PS155, PS157, PS159.	12.5%
Vocational and Higher Education	PS08, PS13, PS15, PS22, PS46, PS49, PS57, PS60, PS62, PS63, PS64, PS68, PS95, PS102, PS110, PS111, PS112, PS129, PS130, PS159, PS164.	11.93%
Cultural Preservation	PS07, PS19, PS31, PS51, PS54, PS69, PS71, PS86, PS97, PS99, PS123, PS126, PS128, PS135, PS150, PS152, PS156, PS166, PS174.	10.80%
Mathematics Education	PS04, PS19, PS53, PS59, PS72, PS76, PS88, PS89, PS102, PS143.	5.68%
Moral and Social Education	PS26, PS41, PS71, PS111, PS123, PS128, PS129, PS152, PS163.	5.11%
Emotional and Behavioral Skills	PS11, PS18, PS23, PS49, PS95, PS132, PS133.	3.98%
Physical Education and Activities	PS21, PS74, PS98.	1.7%

der (ADHD). PS121 proposed an educational game to support children with ADHD, offering games to help them learn English, mathematics, and other subjects. PS132 developed MATS, an app designed to enhance self-regulation in children with ADHD by combining executive and behavioral function training. Additionally, PS139 presented Pocket Sign Language, a mobile app for learning Malaysian sign language through informative trivia games.

In computer science and technology education, mobile educational games are used to teach programming, computational thinking, and cybersecurity. PS38 introduced AR-Quest, a collaborative augmented reality game designed to foster computational thinking skills among primary school pupils. Meanwhile, PS52 developed CS Challenger, a gamified application that focuses on challenging computer science concepts such as object-oriented programming and the theory of computation. PS105 proposed a gamified mobile application as an innovative teaching medium for basic programming subjects with the aim of increasing students' interest. PS140 created an augmented reality serious game to enhance learning in computer networks, organizing the material using Bloom's Taxonomy. PS149 developed Pic2Program, an educational app that uses play to teach computational thinking by helping children guide characters through mazes. PS157 introduced Soceng Warriors, a game designed to raise awareness of social engineering attacks and cybersecurity.

In vocational and higher education, mobile educational games are used to reinforce subject-specific concepts, develop professional skills, and prepare students for the job market. PS22 explored the use of a serious game in a software engineering course, enabling students to confront workplace-related challenges. PS63 developed a mobile application for learning web design that uses gamification to improve the knowledge and performance of Information Technology (IT) students. PS95 investigated the use of the Ace Your Self-Study app, which uses gamification elements to support self-regulated learning processes in university students. PS110 focused on developing a gamified mobile learning application for the Digital Business Models course to facilitate understanding of the material and increase student motivation. Additionally, PS164 developed a serious gaming application to train medical residents in communication skills and improve doctor–patient interaction.

Studies that use mobile educational games to promote and preserve indigenous languages, local traditions, and cultural heritage address cultural preservation. PS54 designed the Enggang Kanayatn Quiz (EKQ) app to teach the Dayak Kanayatn language to children based on pedagogical principles. PS86 developed BAKE, a mobile app for the basic teaching and self-learning of the Shipibo-Konibo language with the aim of preserving local culture. PS123 created Ramadan Spirit, a game designed to educate Muslim children in Malaysia about fasting and good deeds during Ramadan while incorporating cultural values. PS128 developed Kiddy Manner, a game-based app that teaches Thai social etiquette to children and promotes cultural and social values. PS150 proposed designing a mobile app to preserve the Omagua language, which is one of the endangered native languages of the Peruvian Amazon. Finally, PS174 introduced Wawa, a mobile app developed by the Napo River communities in Loreto, Peru, to help people learn the Kichwa language.

In the field of mathematics education, mobile educational games are developed to make learning mathematical concepts more engaging and accessible. PS04 created '7-Day Math', a visual novel game focused on the concept of definite integrals. PS76 developed Pecahanku, a mobile app that uses visual representations and interactive operations to help students learn fractions. PS88 introduced eMATH, an app offering gamified arithmetic lessons and designed to improve learning effectiveness among high school students. PS89 developed 'Math's Going On', a gamified educational app focusing on topics in the third-grade mathematics curriculum, designed to support teachers and parents. PS143 proposed an app that gamifies multiplication table practice, making learning multiplication tables less monotonous for primary school children.

Studies that use mobile educational games to promote ethical values, social awareness, and appropriate behaviors also address Moral and Social Education. PS26 developed a mobile app that teaches children moral values by presenting them with value-embedded scenarios and providing them with options to make decisions based on. PS41 introduced Ethoshunt, a gamified mobile app for teaching and learning ethics. In PS123, Ramadan Spirit also contributes to moral education by teaching children about good deeds during Ramadan. In PS128, Kiddy Manner promotes social etiquette and cultural values to Thai children. Additionally, PS163 examined the impact of gamification on Quranic literacy, fostering an engaging learning environment for religious education.

Studies focusing on emotional and behavioral skills use mobile educational games to support users' personal and emotional development. PS11 developed Kids Stress Relief, a gamified app designed to help preschool children recognize emotions and manage anger. PS23's serious game for heart rate regulation also helps to manage arousal and stress levels. The 'Ace Your Self-Study' app in PS95 supports college students in self-regulating their learning, thereby improving their time management skills and discipline. PS132 presented MATS, which aims to improve self-regulation in children with ADHD by combining cognitive and behavioral training. PS133 developed a memory training app to help seniors maintain their cognitive and motor skills.

Mobile educational games in Physical Education and Activity encourage physical activity and promote healthy lifestyles. PS21 developed Tic-Tac-Training, a game that uses the classic Tic-Tac-Toe concept to motivate people to become more physically active. The Barty game in PS74 combats childhood obesity through nutritional education and encourages physical activity. PS98 presented Fammeal, a gamified app that engages parents and children in developing healthier habits relating to eating, hydration, sleep, and physical activity.

In summary, the selected studies demonstrate the versatility and potential of mobile educational games in diverse educational contexts. The wide range of areas covered, from language learning to emotional and behavioral skills, highlights the significant role of these technologies as effective tools for complementing and enriching teaching and learning processes in different disciplines and populations. Integrating interactive and gamified elements into mobile applications makes learning more accessible, engaging, and tailored to users' specific needs, thereby contributing to positive educational outcomes.

When the distribution of application contexts is analyzed, it becomes clear that the scenario is not uniform. There is a strong concentration of studies in areas such as language learning, health education, and science. This trend can be explained by the nature of these subjects, which often involve memorizing facts and repetitive tasks. On the one hand, this demonstrates the field's ability to offer effective solutions to well-defined, high-demand problems. However, the notably lower representation of essential areas such as mathematics and, in particular, social-emotional skills raises an important question: is the field meeting the most evident demands or following the path of least resistance in design? This creates an opportunity for future research to explore these more complex and abstract domains, which are equally crucial to individuals' development.

5.5 (RQ4) What approaches are adopted to improve human-computer interaction in mobile educational games?

The fourth research question examines how the selected studies enhance human-computer interaction (HCI) and user experience (UX) in mobile educational games. The studies generally demonstrate an increased focus on user-centered design principles, attractive graphics and audio elements, continuous and immediate feedback, reduced navigation barriers, and difficulty level adaptation to the player's profile. Proposals range from careful color and font selection to the use of augmented or virtual reality technologies. The aim is always to ensure engagement, ease of use, and inclusion of diverse audiences, including children, young people, the elderly, and those with physical, cognitive, or sensory disabilities.

Gameplay and User Engagement

Several studies focus on intuitive interfaces and clear navigation to promote a fluid and captivating gaming experience. There is a recurring interest in simpler and cleaner interfaces so that users are not overwhelmed by too much information. Works such as PS03, PS52, PS73, PS97, PS112, and PS143 adopt a minimalist design, avoiding extensive text and excessive instructions in favor of icons, images, and visual feedback that can direct the player's actions more effectively. PS92 features clear home screens, large buttons, and a functional section layout. Generally, games are designed to be user-friendly, with simple controls and clear icons, reducing initial frustration and speeding up the learning curve.

Attractive graphics and sounds are commonly used to increase engagement. Studies such as PS11 and PS24 feature soft colors, large icons, and engaging characters and narration, whereas PS32 and PS128 focus on vibrant colors and simple animations. The choice of colors, fonts, and visual elements demonstrates special consideration for the target audience of the game.

Continuous and immediate feedback is crucial for both gameplay and learning. In PS21, this is achieved through Experience Points (XPs) and levels, while in PS22, real-time feedback keeps users informed of their successes and failures as they play. In PS50, ColourSpot uses encouraging audio and narration to boost engagement, while PS59 and PS63 provide instant feedback on successes and failures. PS83 and PS146 provide audio and visual feedback when the player either succeeds or makes a mistake, while PS85 uses rewarding sounds, colors, and animations to signal progress and motivate the user. Another relevant approach is adapting the difficulty level to the player's profile, as seen in PS81, where the difficulty level dynamically adapts to the needs of children with Autism Spectrum Disorder (ASD).

Several studies take advantage of Augmented Reality (AR) to increase immersion. In PS08, for instance, AR is combined with game-based learning to browse libraries. PS12 and PS118 use AR to teach astronomy and science, enabling three-dimensional interactions that stimulate curiosity. PS141 and PS170 apply AR to teaching anatomy and cellular biology, enabling users to manipulate 3D models. This combination of the real and the virtual makes the content more concrete and meaningful, thereby increasing engagement.

Initial tutorials or contextual instructions make the game mechanics easier to understand. In PS90, for example, the instructions are integrated into the gameplay itself. In PS164, meanwhile, there is a training mode to ease the adaptation phase. In PS123, Ramadan Spirit game provides clear instructions for each stage, while PS46 and PS105 use videos and specific explanations. These strategies reduce the learning curve, allowing users to focus on the educational content. Additionally, social and collaborative features such as multiplayer and chat functions (PS21, PS63, PS111, and PS157) and competition between players (PS90 and PS171) increase engagement and strengthen human interaction.

Accessibility and Inclusion

Ensuring accessibility and inclusion for diverse audiences, including children, young people, the elderly, and those with physical, cognitive, or sensory disabilities, is a fundamental aspect of improving human-computer interaction. Several studies demonstrate the importance of adapting games to specific needs. For instance, PS11 and PS24 cater for different age groups and special needs, ensuring that the content is comprehensible even for preschool children.

PS29 prioritizes large buttons, appropriate colors, and solutions that optimize interaction for users with hearing impairments. PS139 uses visual icons and auditory commands to encourage deaf children to learn sign language. PS01 is designed for people with motor disabilities and features minigames for fine motor rehabilitation with large objects and a clean interface.

Studies such as PS27 and PS106 use soft color palettes and larger buttons for children with Autism Spectrum Disorder (ASD) or Down syndrome, minimizing distractions and sensory overload. PS79, which is aimed at children with Attention Deficit Hyperactivity Disorder (ADHD), and PS86, which is used to teach the Shipibo-Konibo language, focus on using bright colors without exaggeration to capture attention and improve usability. Dynamic adaptation of difficulty levels for children with ASD is another relevant example (PS81).

Several studies demonstrate accessibility through the use of audio and narration to complement texts (PS60, PS65, and PS85). PS14 uses a holographic approach with 3D images and dialogue with a robot to help with vocabulary learning. PS66 uses photos of hospital products to help explain safety protocols. PS133 includes an audio button for reading texts and representative images to make interaction more intuitive for the elderly. These approaches demonstrate efforts to develop interfaces that facilitate interaction for everyone, regardless of their abilities.

In summary, studies aiming to improve human–computer interaction in mobile educational games range from developing intuitive and accessible interfaces to using emerging technologies, gamification, and personalization. This variety of approaches ensures rich, motivating learning experiences that are always aligned with the pedagogical and contextual needs of users, promoting more effective and enjoyable learning.

Analyzing human-computer interaction approaches reveals a field that consciously applies the fundamental principles of usability and user experience design, and that already dominates in this area. Strategies such as providing immediate feedback, creating clean interfaces and incorporating attractive audiovisual elements are nothing new, yet they form the basis of educational games. The most positive aspect is the application of these principles with a strong focus on accessibility, which demonstrates a genuine commitment to adapting experiences for audiences with diverse needs. However, the critical question that emerges is not whether these good practices are adopted, but to what extent. While the studies list the implementation of resources, it is worth asking whether these choices are the result of participatory design processes and rigorous testing with the target audience or whether they represent a more superficial application of general guidelines.

5.6 (RQ5) What game elements are used in educational mobile applications?

The fifth research question aims to identify and analyze the game elements incorporated into the selected studies. These elements, which often originate from gamification strategies, are crucial for increasing user engagement, motivation, and retention, and for facilitating the learning process in a playful and interactive way. The analysis of the selected studies revealed a variety of adopted game elements. The main elements identified and their frequencies are presented in Figure 9.

As can be seen from Figure 9, 24 game elements were identified.

It is therefore evident that the selected studies cover a wide range of game elements aimed at increasing the engagement

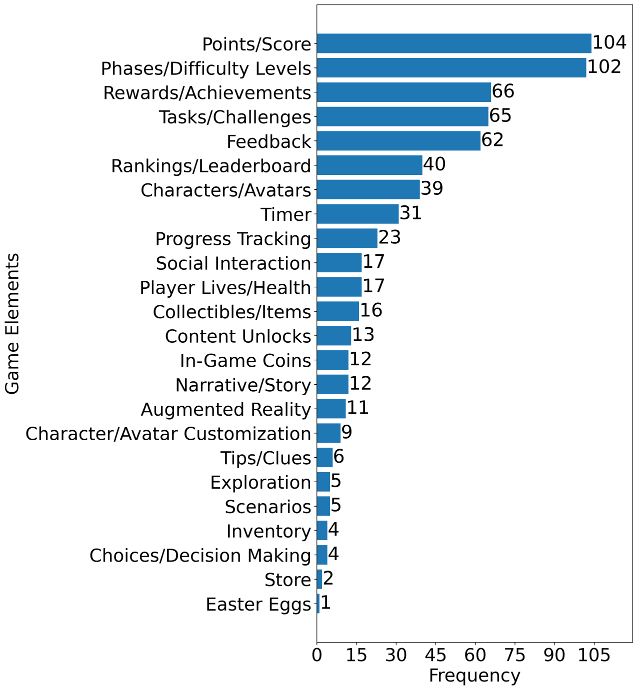

Figure 9. Frequency of Game Elements in Selected Studies.

and effectiveness of mobile educational games. Table 6 in the Appendix presents the studies and their percentages applying each identified game element.

Analyzing the selected studies, it can be seen that educational app developers are using traditional game elements to create more engaging learning experiences. A wide range of game elements are incorporated into mobile educational games to increase engagement and learning effectiveness. These elements make the experience more interactive, motivating, and personalized, meeting users' specific needs and the proposed educational objectives.

One of the most prevalent elements is the points/scoring system. Awarding points serves as a quantitative indicator of the user's progress or performance within the game, providing immediate and measurable feedback. For instance, the Vocab Library app in PS02 uses scoring to motivate children to learn English vocabulary by rewarding them for correct answers. Similarly, the EWORD game for primary school students in PS85 awards points as students learn new words, thereby increasing their engagement. In PS88, the eMATH app uses scoring to encourage secondary school students to improve their arithmetic skills. The fooya! game in PS117 uses points to encourage children to make healthy food choices, and the Foodbot Factory in PS161 uses points to increase nutritional knowledge.

The integration of phases/difficulty levels is equally important. These elements divide the content into progressive stages, enabling users to progress as their abilities improve. PS03 features a 3D board game designed to enhance English vocabulary retention, with the difficulty of the levels adjusting according to the student's progress. PS12 introduces PlanetarySystemGO, which uses levels that gradually deepen to teach astronomical concepts, facilitating comprehension. In PS126, Kabisa App uses difficulty levels to teach the Sundanese alphabet in a structured way, thereby increasing learning effectiveness. PS141 has developed an augmented reality game for learning anatomy, organizing the content into progressively challenging levels.

Rewards/achievements are widely used to recognize users' efforts and encourage them to continue. In PS55, the DivT-Cell app rewards students for learning about cell division, encouraging them to further explore scientific content. In PS90, SAAFE serious game awards achievements to young people for completing sexual health education modules, thereby increasing their interest and engagement. In PS74, Barty game uses rewards to encourage children to adopt healthy habits as part of a strategy to combat childhood obesity. PS102 uses rewards in Gam-Mate to encourage the study of discrete mathematics, while PS169 uses achievements in the Triumf app to support children undergoing medical treatment.

The task/challenge element provides clear, structured goals to guide the player. In PS28, EduPARK uses augmented reality to set challenges that encourage students to explore a park and learn about biodiversity. PS81 developed Pickstar, a game that presents autism-friendly challenges to support vocabulary learning in a playful way. In PS151, QuizHuntAR is a location-based game that uses treasure hunt logic to present educational tasks, promoting active engagement. PS95 incorporates challenges into the 'Ace Your Self-Study' app to support self-regulated learning among university students.

Providing feedback is critical to the educational process as it gives users information about their performance. Apps that provide immediate feedback help users to quickly identify and correct errors, thus reinforcing correct learning. In PS14, holographic English pronunciation practice app provides instant feedback to improve language skills. PS117 describes Fooya!, which provides children with feedback on their food choices, positively influencing their nutritional behaviors. PS171 describes a pronunciation training game that uses feedback to guide players in correcting errors and achieving continuous improvement. PS65 provides feedback in a vocal health quiz and PS154 uses feedback in En-Lang4All to support English learning.

Characters/avatars and narratives/stories enrich the user experience, making learning more personal and meaningful. Customizing avatars enables users to see themselves reflected in the game, thereby increasing empathy and motivation to achieve proposed goals. In PS11, Kids Stress Relief uses characters to help children recognize emotions and manage anger. PS122 features Pets vs. Onco, in which characters help children with cancer to adhere to their treatment, making the process more empathetic. In PS128, Kiddy Manner uses engaging characters to teach Thai social etiquette. PS157 Soceng Warriors uses avatars to raise cybersecurity awareness, while PS164 uses characters to train medical communication skills. Well-developed narratives provide a more immersive experience by contextualizing the game's goals. In PS04, 7-Day Maths uses an engaging narrative in a visual novel format to teach maths. PS127 introduces Kahaniyan, which supports Urdu language learning through interactive storytelling. PS146 uses an arcade-style story to teach organic chemistry in Organic Fanatic, increasing engagement. PS167 incorporates storytelling into Tsunami Fighters to educate people about disasters, and PS169 uses storytelling in Triumf to provide psychological support.

Social interaction is a powerful component that fosters collaboration or competition among users, thereby increasing engagement. Games that facilitate shared activities encourage collaborative learning and knowledge exchange. In PS21, Tic-Tac-Training, for example, expands the classic game of noughts and crosses into a multiplayer format, encouraging physical activity and interaction between players. PS171 describes a pronunciation training game that enables users to share challenges and promotes collaborative learning. In PS94, XplorerAfe+ uses augmented reality to encourage exploration and social interaction in English learning. PS80 uses social interaction in DropQuest to teach chemistry, while PS146 incorporates social components into Organic Fanatic.

Progress tracking and player health/lives allow users to monitor their development and manage their resources within the game. These features promote accountability and encourage strategic decision-making, striking a balance between challenge and accessibility. In PS41, Ethoshunt feature gives students a clear view of their ethics learning progress. PS69 introduces Learn Vienna Karelian, which tracks dialect learning progress and promotes language preservation. In PS88, eMATH enables students to monitor their performance and boost their self-confidence. PS102 uses Gam-Mate tracking to monitor maths learning, and PS95 supports college students in self-regulation. The 'player health' element adds a challenge and encourages students to develop strategies to avoid failure. In PS56, a game for diabetic children requires players to maintain the health of a character called Abood, thereby teaching them about glucose control. PS82 introduces EcoAction, in which players must promote environmental awareness to maintain the health of the environment. PS143 is an app for practizing multiplication tables which uses lives to make learning more challenging. STD PONG 2.0 uses this element to educate players about the risks of sexual behavior, and PS123 applies it to Ramadan Spirit to educate players about fasting.

Collectibles/items and content unlocks encourage users to collect objects and unlock new content as they reach certain milestones. These elements encourage exploration and repetition of activities, thereby enriching the learning experience. In PS07, ThaiFoodAdventure allows players to collect items related to Thai cuisine and learn about local culture. PS38 introduces ARQuest, in which students collect physical and virtual items via augmented reality to develop their computational thinking skills. In PS99, mobile games for cultural heritage encourage visitors to collect items and promote exploratory learning. PS156 uses collectibles to teach Indonesian history and PS176 uses items in the WISE game to make learning more engaging. Content unlocks maintain interest by offering new experiences as the user progresses. In PS19, Math-Hero enables children to unlock new levels by improving their maths skills. PS46 describes a serious game that unlocks content about the world of work to prepare college students for their future careers. In PS74, Barty promotes healthy habits to unlock new activities and help prevent childhood obesity. PS118 applies this concept to science education, while PS103 uses it in games designed for people with phonological dyslexia.

In-game coins and character/avatar customization add layers of interactivity and personalization. In-game coins allow users to purchase items or perks, while customization increases emotional identification with the game. In PS21, Tic-Tac-Training rewards physical activity with virtual currency that can be used to customize avatars. In SAAFE, PS90 uses in-game coins to encourage healthy behaviors by enabling young people to purchase virtual items. In PS113, Green Tycoon, virtual currency is used to teach green chemistry principles, where players invest in sustainable improvements. In Pic2Program, PS149 uses coins to teach computational thinking, and in PS163, they are used to teach the Quran. Character customization increases engagement. In PS03, for example, students customize avatars in a 3D board game, which makes the experience more personal. PS172 enables children with type 1 diabetes to customize characters, thereby facilitating learning about the self-management of the disease. PS155 uses customization in sCool to teach coding and PS169 applies this element in Triumf.

Other less common elements, such as tips/clues, exploration, scenarios, choices/decision-making, inventory, stores, and Easter eggs, also play an important role in creating rich learning experiences. These elements add depth and complexity to games, providing additional support, promoting discovery and encouraging critical decision-making. In PS81, Pickstar provides tips to help children with autism complete tasks and adapt to their needs. PS84 encourages exploration in EduPARK, where students discover the park and learn about the natural environment. In PS13, the inventory feature is incorporated into the university library's wayfinding app to educate users about the available resources. PS20 incorporates Easter eggs to surprise and reward players as they learn to cook.

Time pressure can create a sense of urgency, increasing user excitement and focus. However, it is important to strike a balance to avoid causing anxiety and ensure that gamification complements educational goals. PS18, for example, challenges children to interpret emotions within a time limit, thereby promoting quick reaction skills. PS52 describes CS Challenger, which uses timers to teach computer science concepts and keep students engaged. PS123's Ramadan Spirit incorporates time limits to encourage good deeds during Ramadan. PS94 uses time pressure in XplorerAfe+ to stimulate English learning and PS119 uses timers in EduPARK to increase the level of difficulty.

Augmented reality (AR) provides immersive experiences that make learning more interactive and engaging. Integrating AR enables users to visualize concepts in 3D, thereby enriching their spatial understanding and facilitating the assimilation of abstract concepts. In PS12, PlanetarySystemGO enables students to visualize celestial bodies at actual size, enhancing their understanding of astronomy. PS38 introduces ARQuest, which combines a physical board with 3D AR animations to develop computational thinking skills. PS96 uses an interactive AR game to increase students' knowledge of how to prevent the spread of the virus. PS151 uses AR in QuizHuntAR for educational purposes, and PS119 applies this technology in EduPARK.

Despite the clear benefits, caution is required when applying game elements. It is important to strike a balance in terms of complexity to ensure that gamification does not distract from educational objectives. For instance, while time pressure can increase engagement, it can also cause anxiety if implemented improperly, as some studies have shown. Rankings can discourage those who are not at the top, so it is important to recognize individual effort and promote healthy competition.

There is a growing trend towards incorporating emerging technologies, such as augmented and virtual reality, to enrich the learning experience. These resources provide an opportunity to explore abstract concepts in a more concrete way, enabling more dynamic and engaging interactions. Another innovation is the personalization of the user experience. By collecting and analyzing data on performance, applications can adapt content and difficulty to offer a more personalized and effective learning experience.

Adopting game elements in mobile educational games has proven an effective strategy for boosting engagement and facilitating learning. However, it is important that these elements are integrated in a way that aligns with educational objectives and the characteristics of the target audience. Developers and educators must strike a balance with gamification to prevent distractions or cognitive overload while ensuring the experience remains meaningful and productive.

User diversity is also a critical factor. Special educational needs apps should consider the specific needs of their users. Positive feedback and rewards, for example, can be particularly effective in maintaining the attention and motivation of children with learning disabilities.

A critical analysis of the results reveals a notable focus on game elements associated with extrinsic rewards, such as points, prizes, and levels. This suggests a gamification approach that focuses on immediate behavioral reinforcement mechanics to the detriment of elements that foster intrinsic motivation, such as complex narratives, free exploration, and meaningful decision-making. While these mechanisms are effective for short-term engagement, a strong reliance on them may inadvertently condition learners to associate learning with obtaining rewards rather than cultivating a genuine interest in knowledge or critical thinking. Thus, the configuration of the observed elements may reflect an immature phase in the field where applications still rely more on popular engagement formulas than on deep, intrinsically motivating pedagogical design. This raises questions about the long-term sustainability of learner interest.

While this section has identified and discussed a wide range of game elements and their general applications, it is important to note that the mere inclusion of these artifacts does not ensure effective engagement or pedagogical success. The complex interplay between multiple elements, application context, user profile, and underlying instructional design is crucial. The subsequent research question (RQ6) focuses on a more in-depth analysis of how these elements and other design strategies specifically contribute to engagement and motivation.

5.7 (RQ6) What is the aspect related to user engagement and motivation in mobile educational games?

This research question explores the factors influencing user engagement and motivation in mobile educational games. The presence of gamification elements such as narratives, challenges, personalization, and adaptation has been shown to be a constant feature of these environments, as they contribute to making learning more engaging, enjoyable, and meaningful. Consequently, these factors encourage prolonged and active user participation, giving the games an immersive quality that sets them apart from traditional teaching methodologies.

Adopting typical gamification elements, such as scores and rankings, in PS68, PS95, and PS110 awakens a sense of competition, motivating users to repeat tasks, and improve their performance. Meanwhile, reward systems (such as medals, virtual coins, and item unlocking) provide a sense of progress, victory, and autonomy in PS21, PS37, and PS72, which contributes to players' continued dedication. For example, in PS35, gamification encourages Portuguese language learners to persist in their studies. PS47 presents a cybersecurity education game that uses medals, levels, and narratives to engage users. PS82 suggests that including achievements and global leaderboards makes the game more competitive and enjoyable. PS91 uses reminders and feedback to engage children with speech disorders, showing that health content can also benefit from competitive and reward systems. PS154 and PS161 display scores, progress, and immediate feedback, which reinforces the perception of challenge and achievement, thereby encouraging dedication to the game. In short, applying gamification techniques makes the experience more immersive and stimulating, thereby increasing audience interest and strengthening their commitment to learning.

Including an engaging narrative or context that makes sense to the player also emerges as a powerful motivational tool. In PS24, for example, introducing a story featuring inclusive characters increases engagement among children with dyslexia. In PS30 and PS82, narrative is employed to raise awareness of environmental issues, thereby adding meaning to programming and environmental conservation activities. For example, PS46 presents simulated academic work situations that force students to make decisions and deal with rewards or penalties, while PS40 uses an adventure experience in a museum to keep participants motivated. PS101 focuses on creating characters and items that promote healthy habits, while PS44 and PS125 combine narrative and local culture to generate intrinsic interest and connect educational content to students' lives. Additionally, narrative arouses curiosity in PS84 and gives meaning to game activities in PS29 and PS168, encouraging continued engagement with the material. In PS56, including a character called Abood generates a greater sense of belonging and interest in the topic. These examples demonstrate that engagement increases when learning is anchored in a relevant plot or context.

Another critical factor in maintaining user motivation is the ability to personalize and adapt content. In PS23, for instance, a serious game designed to regulate heart rate adjusts the level of difficulty based on physiological readings, thereby increasing engagement and effectiveness. In PS172, providing real-time feedback and allowing users to choose avatars reinforces their sense of control and identification with the game. Similarly, in PS41 and PS169, allowing users to select a character's gender, change colors and clothes, or acquire new avatars fosters a sense of autonomy and identification. In PS132 (which is aimed at users with ADHD), the adaptive elements and reminders support self-regulation and adherence to training. In PS17, PS23, PS81, and PS111, the content adjusts to the individual learner, promoting more meaningful learning. PS81 uses the Dynamic Difficulty Adjustment (DDA) technique to adapt the complexity of tasks to the abilities of children with ASD, thereby avoiding frustration and demotivation. In specific scenarios, such as PS10 (for dyslexia, dyscalculia, and dysgraphia) and PS24 (for dyslexia only), the game design addresses cognitive and motor limitations to increase inclusion.

Another widely used strategy to increase engagement is the inclusion of social elements, such as competition and cooperation. In PS21, for instance, users are motivated to exercise by competing for and caring for an avatar. In PS17 and PS62, meanwhile, collaboration and competition encourage students to persist with gamified learning activities. PS90 emphasizes the importance of personalizing avatars and competing for higher scores to encourage African-American youth to engage with sexual health topics. Social interactions such as sharing scores with peers (PS47 and PS89) or participating in team games (PS95) generally promote a sense of belonging and recognition, which has a positive impact on motivation.

User engagement and motivation in mobile educational games are therefore linked to a variety of elements, ranging from reward, and challenge structures to rich narratives, and including personalization and social interaction possibilities. These approaches all strengthen the player's interest while creating an immersive, rewarding environment conducive to continued learning. The playful nature of these games not only reinforces the acquisition of knowledge, but also the retention of skills. By combining entertainment and education, mobile educational games promote greater engagement, active participation, and solid learning outcomes, catering to a wide variety of profiles and age groups.

When analyzing the factors of engagement, it becomes clear that the most effective strategies are not random, but seem to address three fundamental psychological needs of the user. First, the need to feel competent, which is met by point systems, immediate feedback, and progressive challenges that generate a sense of mastery. Second, the need for autonomy, which is met by avatar customization and, more sophisticatedly, by difficulty adaptation, which gives the player a sense of control over their learning journey. Third, the need for social connection, stimulated through elements of competition and collaboration. The critical point here is that, although many studies apply one or two of these pillars, the true potential of engagement seems to lie in combining them. An engaging narrative, for example, not only contextualizes the challenge (competence), but can also empower the player's autonomy through choice.

5.8 (RQ7) Who are the target audiences for mobile educational games in terms of age, skill level and special needs?

The analysis of the surveyed studies shows that adapting mobile educational games to consider different age groups and skill levels is essential for positive learning outcomes. Developers and educators must consider elements such as age group, cognitive level, cultural context, specific needs, and knowledge areas when defining appropriate adjustments for each study's target audience. The main user categories covered by the studies are summarized below:

- **Preschool phase (3 to 6 years old)**
  – Some studies (PS06, PS14, and PS34) are aimed at young children, who require simple interfaces with large buttons and engaging content. There are also games designed to develop early literacy skills, such as letter recognition and basic vocabulary,
- **Elementary school (6 to 12 years old)**
  – Most of the studies focus on this age group, involving children from the first (6 to 9 years old) and second (10 to 12 years old) cycles. The content usually covers language (PS02, PS32), mathematics (PS59, PS72), science (PS84), and even moral and value concepts (PS26). Generally, levels or phases are adopted that evolve in complexity to accompany the growth of skills and school knowledge,
- **High school and adolescents (13 to 18 years old)**
  – Some studies (PS04, PS45) address the transition to more specific and in-depth content, including exam preparation and advanced science and mathematics topics. In certain cases, health issues or risk prevention are also discussed (PS90), with the language adapted to the interests of adolescents,
- **University students and adults**
  – There are serious games aimed at higher education that are used in engineering, computing, and business disciplines (PS22, PS30, PS46, and PS110). Some studies focus on undergraduate students aged 18 and over or professionals from various sectors (PS65, PS133), requiring more technical language and complex content,
- **Different skill levels and special needs**
  – **Children with learning disabilities:** game models that adjust the level of difficulty or use multisensory approaches (PS10), as well as simpler and more repetitive interaction modes (PS79),
  – **Children with ASD:** require special attention to the choice of colors and sounds, immediate feedback and ADD techniques (PS17, PS70, and PS81) to adapt the challenge to user engagement,
  – **People with motor disabilities:** interfaces with larger touch targets or voice commands (PS01, PS104),

- **People with visual or hearing impairments:** emphasis on subtitles, audio narration, and enhanced visual elements (PS32, PS139), depending on the type of limitation.

As detailed above, the categories of users demonstrate that the analyzed mobile educational games seek to serve a broad audience, from preschoolers to adults undergoing professional training. Particular attention is also given to individuals with different abilities and special needs. Identifying these different audiences and the particularities of the games developed for each one highlights the field's tendency to create playful solutions for specific contexts and user profiles, thus seeking greater relevance and potential educational impact.

Analysis of the target audience for mobile educational games shows that, despite covering different age groups, the field focuses its efforts more intensely on two main groups: schoolchildren and users with special needs. In primary school, the foundations of learning are established, and in the area of special educational needs, games offer a level of personalization and engagement that traditional methods often cannot provide.

5.9 (RQ8) What is the impact of educational games on the teaching and learning process on mobile devices?

This research question aims to analyze the influence of mobile educational games on the teaching and learning process. The reviewed studies generally reveal a wide range of benefits, including increased motivation, engagement, and interest in the subject, as well as improved academic performance, knowledge retention, and the development of cognitive, social, and emotional skills.

Evidence from the selected studies shows that using mobile educational games has a positive impact on several aspects of the teaching and learning process.

One of the most notable effects is increased student engagement. Different studies show that introducing playful elements awakens curiosity, making classes more appealing. For instance, PS04 found that using a visual novel game to teach mathematics increased students' interest in the subject, and PS12 revealed that Year 4 children were more motivated to learn astronomy with an augmented reality game than with traditional methods.

PS14, which focused on English pronunciation, revealed greater motivation and active participation among children, leading to improved performance compared to conventional teaching methods. The 7-Day Maths game in PS04 increased curiosity about mathematical topics, and ThaiFoodAdventure in PS07 significantly increased interest in food heritage.

Several studies have also pointed to significant improvements in content retention and academic performance. For instance, PS22, which was used in a Software Engineering course, revealed that students' grades increased considerably after playing the game. Meanwhile, PS53 showed that elementary school children's speed and accuracy in mathematical calculations improved. The research group responsible for Foodbot Factory (PS161) and the Ramadan Spirit game (PS123) found that game elements maintained acquired knowledge and changed behavior.

Furthermore, PS60, which focused on PLC wiring, and PS67, which focused on irregular verbs in English, showed statistically significant improvements between the pre- and post-tests, which reinforced learning gains. Similarly, 7-Day Maths (PS04) and CS Challenger (PS52) exemplify how a game-based approach can increase content assimilation and lead to better formal assessment results.

Mobile educational games facilitate the acquisition of conceptual knowledge and stimulate the development of cognitive skills. The most important of these are problem solving (PS03, with vocabulary on a 3D board), critical thinking (PS68, through analyzing health claims), fine motor coordination (PS01), linguistic awareness (PS33, in spelling training), and socio-emotional skills (PS49, in developing social skills in university students).

Another interesting finding is the improvement in emotional self-regulation and self-control observed in PS23 and PS11. PS23 used cardiorespiratory biofeedback, while PS11 focused on anger management in preschool children. Several studies indicate that educational games create less stressful environments, encouraging students to experiment, and learn from their mistakes without fear of judgement. PS23 describes how this strategy can help with emotional control, while PS117, which focuses on eating habits, shows that the enjoyable nature of the game reduces anxiety about behavioral changes. This approach reinforces learning through trial and error, which is essential for long-term retention of content.

As well as expanding theoretical knowledge, games can develop skills such as problem solving, teamwork, and critical thinking. For example, in PS22, students faced challenges that simulated a professional environment, and in Math-Hero (PS19), children from marginalized communities improved their mathematical reasoning and cultural values.

In topics related to health, citizenship, and awareness (PS45, PS48, PS60, and PS90), there are signs that users tend to apply what they learn in real life, for example by adopting healthier eating habits, sustainable practices, or preventive behaviors such as respecting traffic rules, preventing sexually transmitted diseases and dealing with natural disasters. The FightHPV (PS101) and Pets vs Onco (PS122) games demonstrate that the playful experience encourages reflection and more responsible attitudes in everyday life. This contributes to compliance with health treatments and disease prevention. Numerous studies provide quantitative evidence of the effectiveness of educational games, demonstrating significant improvements in test scores (PS22, PS67, PS88) and reductions in cognitive load (PS162). Qualitative results also suggest that students perceive learning as more enjoyable (PS82), meaningful (PS09), and effective (PS52), as well as easier to incorporate into their routine (PS19 and PS45).

As they can be played anywhere and at any time, and offer autonomous interaction, mobile educational games can be used to supplement studies outside the school environment. Many studies, such as PS63, PS89, and PS119, emphasize the value of hybrid learning, whereby students can review content at home or even during outings, making use of technology.

In summary, the analyzed studies demonstrate the positive impact of mobile educational games on the teaching and learning process. These tools make learning more motivating and enjoyable, and generate proven increases in performance and content retention, as well as developing cognitive and socio-emotional skills. As well as providing support for students with specific difficulties and encouraging autonomy and personalized study, games increase content relevance and contextualization and can even influence behaviors and attitudes. Consequently, mobile educational games emerge as versatile and powerful tools capable of enhancing the quality and effectiveness of education in various contexts.

The studies demonstrate benefits ranging from increased engagement and academic performance to the development of socio-emotional skills and the application of knowledge in real life. However, a critical analysis requires an examination of the nature of this evidence. It is necessary to consider the possibility of publication bias in this field — the tendency for studies with positive results to be published more frequently than those with null or negative results. This means that the optimistic scenario observed may not represent the totality of attempts, but rather a compilation of cases of success. Furthermore, many of the impact measurements focus on short-term gains. The question that remains is the sustainability of these effects: does the increase in motivation and performance persist for months after the end of the game intervention? Therefore, although the current evidence is fundamental to validating the potential of these tools, the next phase of research needs to go beyond proving that they ”work”.

5.10 (RQ9) How is the evaluation of these mobile educational games being carried out?

Evaluating educational games in mobile applications is crucial to determining their effectiveness, usability, and impact on the learning of the target audience. The studies analyzed employ a variety of evaluation methods, ranging from quantitative techniques to qualitative approaches, to gain an in-depth understanding of how these games perform and are accepted by users. The evaluation methods identified and their frequencies are presented in Figure 10.

As shown in Figure 10, several types of evaluation were identified, each with specific objectives and characteristics.

Table 3 shows the number and percentage of studies in each evaluation type.

Several studies have used questionnaires to evaluate user experience and application effectiveness. In PS85, pre- and post-test questionnaires were used to investigate participants' impressions of the EWORD game, which was designed to help people learn English. PS93 used questionnaires to evaluate the acceptance and effectiveness of a virtual reality application for learning English, while PS114 used questionnaires to assess satisfaction, performance, and areas for improvement following students' interaction with the application.

Pre- and post-tests were also used in PS74, which compared children's knowledge of healthy eating habits before and after they played the Barty game. PS90 adopted a similar approach when evaluating the effectiveness of a serious game on sexual health for African-American youth, analyzing the increase in knowledge between the two tests. PS23 combined pre- and post-tests with physiological parameters to evaluate the impact of a serious game on heart rate self-regulation. Statistical analyses are evident in studies such as PS161, which examined significant differences in nutritional learning between groups that did and did not use a mobile game. PS88 applied paired t-tests to evaluate the effectiveness of eMATH in teaching arithmetic. Projects such as PS01 and PS109 used usability testing. In PS01, physiotherapists assessed the ease of use of mini-games for motor rehabilitation. In PS109, the System Usability Scale (SUS) was used to assess the usability of MedScrab. PS92 combined usability testing with questionnaires to analyze the interface of Erudite Survivor, an application designed to raise awareness of disasters.

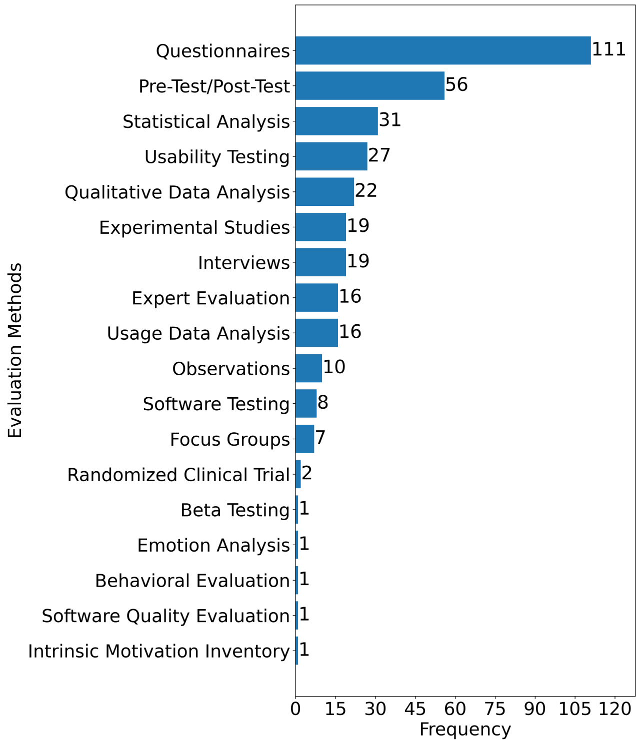

Figure 10. Frequency of Evaluation Methods in selected studies.

PS148 used qualitative data analysis, combining quantitative methods with interviews and qualitative analysis, to understand perceptions about sex education. PS114 analyzed open-ended questionnaire responses to interpret students' opinions about the health promotion application. PS132 conducted a qualitative analysis based on interviews with parents and children regarding MATS, an application designed to help manage ADHD.

In PS145, interviews were conducted after direct observations of the Foodbot Factory to better understand students' satisfaction with a nutrition game. PS132 also conducted interviews with families of children with ADHD to gain a more detailed understanding of their engagement with the MATS app. PS60 included expert evaluation, where IT and PLC experts assessed the content and functionality of a game for teaching programmable logic controllers to ensure technical and pedagogical quality. PS103 consulted with teachers, tu-

Table 3. Distribution of Studies in Evaluation Methods

Evaluation Method	Studies	Percentage
Questionnaires	PS01, PS02, PS04, PS07, PS12, PS14, PS19, PS21, PS23, PS26, PS27, PS28, PS30, PS31, PS35, PS36, PS38, PS40, PS41, PS43, PS44, PS45, PS46, PS47, PS48, PS49, PS51, PS52, PS53, PS54, PS57, PS58, PS60, PS62, PS63, PS68, PS69, PS71, PS72, PS73, PS74, PS75, PS76, PS77, PS78, PS79, PS82, PS84, PS85, PS87, PS89, PS90, PS91, PS92, PS93, PS95, PS96, PS97, PS98, PS99, PS101, PS102, PS104, PS105, PS107, PS108, PS109, PS110, PS111, PS112, PS113, PS114, PS118, PS119, PS121, PS123, PS124, PS125, PS126, PS129, PS130, PS133, PS134, PS136, PS137, PS138, PS139, PS141, PS144, PS145, PS146, PS147, PS148, PS149, PS151, PS152, PS154, PS155, PS156, PS159, PS160, PS162, PS163, PS164, PS165, PS168, PS169, PS170, PS171, PS173, PS176.	63.07%
Pre-Test / Post-Test	PS07, PS08, PS09, PS13, PS14, PS22, PS29, PS30, PS32, PS37, PS44, PS47, PS55, PS57, PS59, PS60, PS63, PS66, PS67, PS70, PS71, PS72, PS73, PS74, PS80, PS83, PS86, PS88, PS89, PS91, PS96, PS100, PS101, PS102, PS108, PS113, PS115, PS118, PS120, PS122, PS127, PS128, PS135, PS136, PS143, PS150, PS155, PS157, PS158, PS161, PS162, PS166, PS167, PS173, PS174, PS175.	31.82%
Statistical Analysis	PS09, PS24, PS25, PS30, PS39, PS41, PS42, PS49, PS50, PS65, PS70, PS73, PS75, PS88, PS89, PS106, PS108, PS109, PS111, PS117, PS118, PS119, PS122, PS129, PS133, PS134, PS140, PS157, PS161, PS163, PS164.	17.61%
Usability Testing	PS01, PS20, PS27, PS31, PS46, PS58, PS61, PS69, PS81, PS84, PS85, PS86, PS88, PS90, PS91, PS92, PS99, PS104, PS109, PS110, PS112, PS120, PS138, PS141, PS142, PS150, PS170.	15.34%
Qualitative Data Analysis	PPS11, PS13, PS28, PS41, PS45, PS48, PS51, PS57, PS71, PS94, PS109, PS114, PS116, PS122, PS137, PS147, PS148, PS149, PS155, PS158, PS170, PS172.	12.50%
Experimental Studies	PS23, PS29, PS37, PS40, PS50, PS70, PS80, PS83, PS86, PS100, PS102, PS106, PS115, PS117, PS135, PS140, PS161, PS166, PS175.	10.80%
Interviews	PS11, PS38, PS51, PS56, PS66, PS71, PS81, PS94, PS96, PS109, PS115, PS128, PS131, PS132, PS145, PS148, PS153, PS169, PS172.	10.80%
Expert Evaluation	PS33, PS55, PS59, PS60, PS61, PS63, PS64, PS69, PS82, PS100, PS103, PS105, PS110, PS124, PS172, PS173.	9.09%
Usage Data Analysis	PS10, PS17, PS18, PS42, PS47, PS65, PS68, PS101, PS107, PS117, PS119, PS129, PS144, PS167, PS169, PS171.	9.09%
Observations	PS38, PS45, PS56, PS71, PS94, PS121, PS131, PS132, PS145, PS172.	5.68%
Software Testing	PS34, PS64, PS76, PS110, PS123, PS124, PS152, PS156.	4.55%
Focus Groups	PS21, PS56, PS68, PS74, PS90, PS101, PS116	3.98%
Randomized Clinical Trial	PS16, PS25.	1.14%
Software Quality Evaluation	PS03.	0.57%
Intrinsic Motivation Inventory	PS13.	0.57%
Beta Testing	PS02.	0.57%
Behavioral Evaluation	PS16.	0.57%
Emotion Analysis	PS14.	0.57%

tors and IT professionals to validate a game for children with phonological dyslexia, ensuring the accuracy and relevance of its content.

PS17 includes an analysis of usage data, which assessed the progress of children with reading difficulties through game logs. PS117 includes an analysis of telemetry from Fooya!, which assessed the impact of the game on children's food choices. PS171 examined interaction events in the pronunciation game to identify engagement levels and areas of difficulty. Experimental studies appear in PS22, which had a control group and an experimental group to evaluate the use of a serious game in software engineering, and in PS67, in which an experimental group using an English learning game obtained better results than the control group. PS23 also adopted an experimental design to compare groups in relation to physiological self-regulation.

Direct observations were carried out in PS94 to analyze student behavior when using XplorerAfe+ during English lessons. In PS121, the engagement of children with ADHD with an educational game was observed. PS132 also used observations to understand the reactions to, and dynamics of using, the MATS application. PS34 included software tests, such as Black-Box Testing, to ensure the functionality of the Alphazzle application, while PS76 validated the proper functioning of a fractions application. PS100 used ISO 25010 software quality criteria to evaluate a first aid application.

Focus groups were employed in PS74 to bring together children and health professionals to improve Barty, and in PS90 to bring together young people to discuss the content and design of SAAFE. A randomized clinical trial, a more rigorous type of experimental study, was conducted in PS117 to prove the impact of Fooya! on children's food choices. Beta testing took place in PS123, where Ramadan Spirit was offered to a select audience prior to launch in order to gather feedback, and in PS142, where Helpdys was tested with dyslexic children. Software quality evaluation based on ISO/IEC 9126 is taking place in PS03 and PS100 to ensure reliability and efficiency.

PS112 used the Intrinsic Motivation Inventory to measure user motivation when using an online learning application, while PS165 used behavioral evaluation to analyze whether the Traffic Trafik Moris game changed participants' attitudes. Emotional responses to learning English pronunciation were investigated in PS14 using emotion analysis, while activity-based evaluation in PS42 measured the performance of children with autism when forming associations in the game.

In summary, the above examples demonstrate the diverse and combined use of evaluation methods. Through methods such as questionnaires, pre- or post-tests, usability tests, statistical analysis, interviews, observations, expert evaluations, analysis of usage data, experimental studies, and more, researchers can obtain robust evidence and gain insight into the pedagogical effectiveness, usability, intrinsic motivation, behavioral impact, and emotional engagement provided by mobile educational games from multiple angles. These approaches contribute to the continuous improvement of the design, application, and development of these technological educational resources.

The evaluation of mobile educational games relies on two main pillars: measuring user perception, predominantly through questionnaires, and assessing knowledge gain through pre- and post-tests. Questionnaires are used predominantly. Although they are valuable tools for capturing perceived satisfaction and engagement, caution is needed, as a positive evaluation does not necessarily equate to effective learning. A game may be highly rated for being entertaining, but have a superficial pedagogical impact. The presence of other methods, such as data analysis, observations, and performance tests, shows that researchers are aware of this limitation and seek a more complete view. Therefore, it is interesting not only to choose a method, but also to combine different sources of evidence. The most robust evaluations are those that can cross-reference the data, demonstrating that a game not only "pleases" the user, but also "teaches" and "engages" them productively.

5.11 (RQ10) What are the most commonly used game mechanics in educational mobile applications?

This research question seeks to identify and analyze the main game mechanics adopted in mobile educational games. The aim is to understand which game styles are predominant and the trends and preferences of developers and users. Game mechanics refer to the fundamental dynamics that define how players interact with the system, the goals they pursue and how learning is incorporated into gameplay.

These mechanics cover a wide range of approaches, including quiz games, puzzles, narratives, augmented reality, board games, RPGs, and simulations, as well as gesture control. Integrating these different mechanics aims to make the learning experience more attractive, interactive, and motivating, enabling users to acquire new knowledge in a playful and engaging way. Based on the data collected from the analyzed studies, it was possible to categorize the different game mechanics adopted to meet specific educational objectives. Figure 11 shows the frequency of each type of mechanic identified.

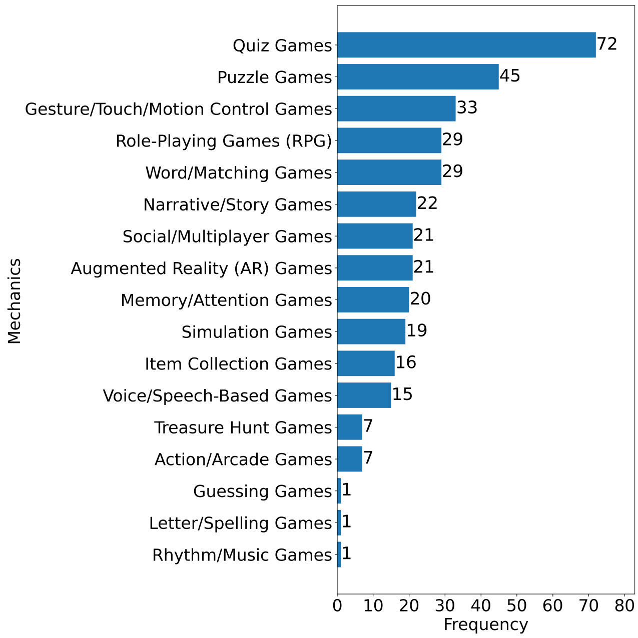

Figure 11. Frequency of Game Mechanics in selected studies.

As shown in Figure 11, several types of mechanics were identified, each of which contributes to a specific type of interaction and learning experience. Below, we provide a brief description of each mechanic:

- **Quiz Games**: They involve multiple choice, true or false, or fill-in-the-blank questions, providing immediate feedback. They allow for the assessment and reinforcement of knowledge, motivating the student to improve their performance,
- **Puzzle Games**: They challenge logical reasoning, problem-solving, and creativity through puzzles, riddles, and complex cognitive tasks,
- **Gesture / Touch / Motion Control Games**: They explore sensory capabilities of the mobile device (touch,

drag and drop, gyroscope, accelerometer),

- **Word / Matching Games**: They focus on the correct association of words, letters, images, or concepts. These games reinforce vocabulary, spelling, semantic understanding, and language skills,
- **Role-Playing Games (RPG)**: They allow students to take on roles, interact with characters, complex narratives, and rich scenarios, stimulating empathy, decision-making, contextualization of content, and intrinsic motivation,
- **Narrative / Story Games**: They use plots and characters to contextualize learning,
- **Social / Multiplayer Games**: They promote interaction between multiple users, encouraging collaboration, healthy competition, communication, and the development of socio-emotional skills,
- **Augmented Reality Games**: They integrate virtual elements into the real environment, creating immersive and contextualized experiences, bringing the content closer to the user's daily life,
- **Memory / Attention Games**: They train information retention, focus, and concentration, essential cognitive skills for long-term learning,
- **Simulation Games**: They reproduce real-world scenarios, allowing students to experiment, test hypotheses, and make decisions without risks, developing critical thinking and practical application of knowledge,
- **Item Collection Games**: They stimulate exploration, motivating the student to collect resources, unlock content or obtain rewards, increasing engagement and persistence,
- **Voice / Speech-based Games**: They require speech production or recognition, helping to develop pronunciation, intonation, listening comprehension and oral language skills,
- **Treasure Hunt Games**: They challenge the user to find clues, markers or objects in a space (real or virtual),
- **Action / Arcade Games**: They focus on dexterity, agility and quick reflexes, making learning more dynamic and stimulating immediate decision-making,
- **Letter / Spelling Games**: They aim to practice spelling words correctly, reinforcing spelling and recognition of linguistic patterns,
- **Guessing Games**: They challenge the player to identify words, objects or concepts from limited clues, developing inference, deduction and creativity,
- **Rhythm / Music Games**: They involve sound and temporal patterns, improving motor coordination, auditory perception, musical memory and attention to patterns.

Table 4 shows the number and percentage of studies that used each identified game mechanic.

The analysis of these studies reveals several game mechanics that are used in mobile educational games. These include quiz games, puzzle games, gesture/touch/motion control games, word/matching games, RPG games, narrative/story games, social/multiplayer games, augmented reality (AR) games, memory/attention games, and simulation games. These mechanics are applied in various ways and pedagogical contexts to increase engagement and learning effectiveness.

For instance, Quiz Games provide immediate feedback by challenging students to answer questions about the content. PS02, for example, integrated a quiz module into English vocabulary learning, enabling children to answer audiovisual questions and reinforce their learning. PS84 combined AR and quizzes in a park for interdisciplinary learning and PS117 assessed nutritional knowledge after mini-games on the topic. PS161 tested retention of nutrition concepts through quick questions, while PS93 integrated quizzes with virtual reality to teach English. PS29 used quizzes to test Arabic sign language learning, helping children with hearing impairments. In computer science, PS52 introduced quizzes to test understanding of complex programming concepts. In health settings, PS122 incorporated quizzes after mini-games related to childhood cancer to ensure that children understood information about self-care.

In addition, PS68 developed a serious game to encourage college students to think critically about health information. The game used a quiz format to challenge students to identify correct and incorrect information, thereby promoting critical analysis skills. In PS35, quizzes were used to test Portuguese vocabulary recall, increasing motivation through rankings and rewards. PS54 combined lessons in the Dayak Kanayatn language with quizzes to consolidate learning, and PS85 used an interactive EWORD quiz to test English spelling. PS141 used AR for anatomy and incorporated quizzes to assess users' knowledge after they had interacted with the content. These examples illustrate how quizzes can be easily adapted to different topics, ranging from languages to nutrition and science.

Puzzle games develop logical reasoning and problem-solving skills. For example, PS30 developed a game that combines puzzle solving with programming and sustainability issues, encouraging players to reduce pollution in a virtual city through reasoning. PS37 used AR to teach programming logic and PS149 presented the Pic2Program game in which students had to solve mazes through sequences of commands to develop computational thinking. PS08 combined puzzles and AR in the university's makerspace, while PS176 incorporated quiz and puzzle elements that required correct answers to progress through challenges.

In PS38, augmented reality was used to integrate puzzles and teach computational thinking skills. Students interacted with physical and virtual elements to solve challenges, making learning more dynamic. In PS55, DivTCell added word-guessing games and jigsaw puzzles to reinforce understanding of cell division. PS61 and PS120 used chemistry and biology puzzles to encourage conceptual understanding, increasing the level of difficulty. These examples demonstrate that puzzles can reinforce cognitive skills in diverse contexts such as programming, science, and logical thinking.

In the case of Gesture/Touch/Motion Control Games, PS01 used pinch-based mini-games to support motor rehabilitation therapy and PS09 introduced a gyroscope-controlled 3D spelling game to reinforce spelling through differentiated controls. PS23 integrated heart rate-related motor control; PS115 and PS168 used touch and drag-and-drop controls to manipulate objects and complete learning activities; and PS142 required precise touch control to complete words.

Table 4. Distribution of Studies in Game Mechanics

Game Mechanic	Studies	Percentage
Quiz Games	PS02, PS12, PS13, PS15, PS19, PS26, PS28, PS29, PS31, PS35, PS43, PS44, PS51, PS52, PS54, PS55, PS57, PS58, PS59, PS62, PS64, PS65, PS66, PS67, PS68, PS69, PS71, PS73, PS77, PS80, PS84, PS87, PS88, PS89, PS92, PS99, PS102, PS105, PS107, PS111, PS112, PS113, PS118, PS119, PS120, PS121, PS122, PS124, PS126, PS128, PS131, PS137, PS139, PS141, PS144, PS145, PS146, PS148, PS151, PS154, PS156, PS158, PS159, PS160, PS161, PS164, PS165, PS167, PS170, PS172, PS173, PS176.	40.91%
Puzzle Games	PS03, PS08, PS21, PS27, PS30, PS31, PS34, PS37, PS38, PS44, PS50, PS51, PS57, PS60, PS63, PS64, PS70, PS75, PS76, PS79, PS80, PS88, PS91, PS97, PS101, PS109, PS115, PS120, PS124, PS125, PS126, PS127, PS128, PS129, PS132, PS133, PS140, PS143, PS144, PS145, PS147, PS149, PS155, PS162, PS175.	25.57%
Gesture / Touch / Motion Control Games	PS01, PS09, PS23, PS27, PS43, PS47, PS50, PS51, PS60, PS61, PS66, PS76, PS81, PS88, PS93, PS106, PS114, PS115, PS123, PS124, PS126, PS132, PS133, PS136, PS140, PS141, PS149, PS152, PS153, PS155, PS162, PS168, PS170.	18.75%
Word / Matching Games	PS02, PS32, PS33, PS35, PS39, PS42, PS55, PS61, PS67, PS69, PS70, PS73, PS75, PS78, PS81, PS83, PS85, PS97, PS106, PS107, PS109, PS116, PS124, PS127, PS131, PS142, PS151, PS154, PS165.	16.48%
Role-Playing Games (RPG)	PS05, PS16, PS22, PS45, PS46, PS48, PS49, PS53, PS56, PS59, PS72, PS74, PS78, PS82, PS85, PS90, PS98, PS108, PS117, PS122, PS123, PS125, PS127, PS129, PS137, PS138, PS147, PS152, PS157.	16.48%
Narrative / Story Games	PS04, PS05, PS22, PS26, PS43, PS47, PS59, PS71, PS93, PS99, PS110, PS127, PS128, PS144, PS145, PS155, PS157, PS160, PS161, PS164, PS167, PS175.	12.50%
Social / Multiplayer Games	PS03, PS12, PS18, PS21, PS38, PS41, PS49, PS51, PS62, PS63, PS87, PS94, PS110, PS116, PS130, PS134, PS147, PS148, PS167, PS171, PS176.	11.93%
Augmented Reality Games	PS08, PS12, PS28, PS36, PS37, PS38, PS42, PS43, PS84, PS94, PS96, PS111, PS118, PS119, PS136, PS140, PS141, PS143, PS151, PS160, PS170.	11.93%
Memory / Attention Games	PS10, PS11, PS17, PS24, PS25, PS29, PS32, PS70, PS79, PS81, PS83, PS103, PS120, PS121, PS124, PS131, PS132, PS133, PS142, PS169.	11.36%
Simulation Games	PS30, PS45, PS46, PS56, PS72, PS74, PS90, PS100, PS113, PS117, PS122, PS125, PS129, PS137, PS147, PS155, PS165, PS172, PS173.	10.80%
Item Collection Games	PS07, PS13, PS44, PS49, PS62, PS102, PS110, PS113, PS117, PS123, PS128, PS144, PS145, PS151, PS152, PS176.	9.09%
Voice / Speech-Based Games	PS09, PS10, PS14, PS17, PS40, PS91, PS103, PS104, PS108, PS135, PS150, PS166, PS168, PS171, PS174.	8.52%
Treasure Hunt Games	PS28, PS41, PS84, PS99, PS111, PS119, PS151.	3.98%
Action / Arcade Games	PS143, PS146, PS152, PS156, PS158, PS165, PS172.	3.98%
Letter / Spelling Games	PS09.	0.57%
Guessing Games	PS18.	0.57%
Rhythm / Music Games	PS24.	0.57%

These examples demonstrate how sensory interaction can make learning more immersive, inclusive, and accessible to different audiences and needs.

Word/matching games, which involve pairing words and images as well as organizing letters and words, are widely used in contexts of literacy and vocabulary development. For instance, PS35 incorporated cross-language correspondences to facilitate Portuguese learning, and PS85 developed an educational mobile game to teach English vocabulary, in which users matched words to images or synonyms to reinforce memorization and comprehension. PS142 used this mechanic to teach reading and writing to dyslexic children by allowing them to complete words in order to reinforce literacy skills. PS118 and PS123 expanded vocabulary by associating words and images, and PS131 used games involving choosing the correct option and word formation to reinforce vocabulary and semantic association. These approaches facilitate the acquisition of language skills in a playful and meaningful way.

In RPG games, which are characterized by complex narratives and the possibility for students to take an active role, PS74 developed Barty, a serious RPG game to combat childhood obesity by promoting healthy eating habits. PS90 introduced sex education through narratives and choices. PS117 simulated battles against unhealthy foods to teach nutrition. PS22 used an RPG to teach software engineering content.

PS123 addressed cultural and religious values in narrative missions, highlighting the versatility of RPGs in providing context and motivation for players.

In narrative/story games, which use plots to contextualize content, PS05 developed a narrative game for children with asthma, showing everyday situations in which to practice self-care. PS40, in turn, used a narrative to encourage visits to the museum and engagement with scientific content. PS129 explored educational aspirations through storylines and PS164 enhanced doctor–patient communication with immersive narratives. PS123 and PS152 featured narrative games in which players completed missions by collecting good deeds, thereby reinforcing cultural and religious values. PS22, for instance, employed a professional narrative to challenge software engineering students in the workplace. These narratives stimulate emotional immersion, curiosity, and knowledge retention.

In social/multiplayer games, which promote interaction, collaboration, and competition, PS21 adapted tic-tac-toe for an educational context to encourage active school travel. PS38 created ARQuest, a collaborative game designed to foster computational thinking, while PS87 introduced multiplayer quizzes to make practice more enjoyable and challenging. PS112 encouraged social interaction in web design courses and PS171 proposed asynchronous pronunciation challenges to promote continuous engagement and peer learning. These examples demonstrate how incorporating a social element can increase motivation, facilitate knowledge exchange, and promote the development of socio-emotional skills.

AR games create immersive environments that integrate virtual elements with the real world. PS12 developed an AR game for teaching astronomy, in which users captured planets and answered questions. PS28 and EduPARK, as well as PS36 and AR-Child, used AR to make learning more contextualized and interactive. In PS42, AssociAR game used AR to help autistic children learn by associating images and words, while PS84 and PS170 integrated AR with quizzes and exploration to stimulate curiosity and observation of the environment. PS140 applied AR to teaching computer networks. Thus, AR brings content closer to everyday life, making it more meaningful.

PS79 created Dilud to reinforce working memory in children with ADHD by focusing on Memory/Attention Games, which train essential cognitive skills. Meanwhile, PS133 developed a memory training app for the elderly. PS17 and PS25 also implemented practices aimed at reinforcing memory and attention, thereby improving the cognitive skills of different groups of learners. PS10, PS24, and PS81 addressed various aspects of attention and information retention. Such mechanics strengthen fundamental cognitive functions for learning.

Simulation games allow experimentation in realistic scenarios without risk. PS56 created a game about diabetes to encourage understanding of glucose control and healthy habits. PS74 and PS98 focused on eating habits and exercise. PS74 and PS98 focused on balanced eating and physical activity, while PS100 and PS117 simulated emergency situations (e.g. first aid) and food choices. PS110 applied simulation to digital business models and PS164 simulated medical scenarios to improve communication. These simulations help students to understand the consequences of their actions, apply their knowledge, and develop their critical thinking skills in realistic contexts.

In short, the wide range of game mechanics employed in mobile educational games demonstrates the developers' creativity and attention to detail in combining playful and pedagogical elements. Through quizzes, puzzles, narratives, augmented reality, word games, collecting items, memory games, simulations, and social interactions, these applications create engaging, relevant, and flexible learning experiences. When these mechanics are well integrated into the content, they make learning more effective, meaningful, and stimulating for different age groups, knowledge areas, and educational needs.

An analysis of game mechanics reveals a strong preference for formats such as quizzes and puzzles. These mechanics align perfectly with traditional teaching models focused on evaluation and knowledge reinforcement, and are highly effective for testing memory and solving problems with defined answers. However, this dominance obscures the potential of less utilized, yet pedagogically more engaging, mechanics such as Simulation and RPG. While a quiz asks "What is the answer?", a simulation asks "What happens if...?" This difference is fundamental, given that the former focuses on reproducing knowledge, while the latter promotes building and applying that knowledge in complex systems. The current scenario suggests that the field is largely more focused on making content review more entertaining than on creating new environments for discovery. The challenge for the future is not to abandon quizzes, which have their value, but to balance the portfolio of mechanics, investing more in experiences that allow students not only to prove that they know, but also to explore, make mistakes, and build their own understanding more deeply.

6 Discussion

This section critically interprets the findings presented in Section 5, relating them to theoretical references and evidence from similar research. The discussion is therefore structured around an analysis of the factors influencing the adoption of mobile educational games. This analysis considers elements such as technologies and platforms, development methodologies, application contexts, and future challenges and opportunities. The intention is to relate these points to reflections already presented in this article, providing a critical overview of the main findings.

One of the central findings of this study was the widespread adoption of Unity as the main game engine, alongside the presence of other development tools, such as Flutter, Android Studio, and programming languages like C#, Java, and Dart. While the inclusion of robust technologies facilitates the creation of interactive and immersive environments, it also requires pedagogical planning that goes beyond the use of isolated digital resources.

Clearly, the mere availability of game engines or development kits does not guarantee a positive impact on learning. Teachers and development teams must consider the pedagogical purpose of each resource to ensure cohesion between educational objectives, game design, and student needs. This reflects experiences in hybrid teaching approaches, where technology is a means to greater engagement and autonomy rather than an end in itself.

When analyzing the methodologies used (ADDIE, MDLC, Scrum, and User-Centered Design, to name a few), it becomes clear that there are various initiatives aimed at incorporating systematic processes into the creation of gamified applications. This variety can contribute to the quality of the final product, as each model addresses specific requirements, ranging from rapid prototyping to formative evaluation with real users. We can also note that even research methodologies were used for the development of a mobile application, as was the case with the DSR methodology for the development of a mobile application aimed at memory training for the elderly. Although DSR is traditionally associated with academic research, in this specific context, its application was explicitly reported as an agile and flexible methodology for the practical and iterative development of the educational game.

However, a recurring challenge is the lack of long-term evaluations and robust comparative studies in terms of both pedagogical performance and effective engagement. Future developers and educators are advised to plan continuous assessment stages to evaluate whether games achieve their educational objectives, while maintaining a focus on practical applicability and ensuring solutions are tested in real contexts involving teachers and students at all stages. This attention to validation not only strengthens scientific rigor, but also increases the legitimacy of games as pedagogical tools.

The results show that mobile educational games are adopted in various scenarios, particularly for language learning, health education, exact sciences, and inclusion/accessibility. This scope highlights the potential of such tools for adapting curricula, as they enable content to be explored in a playful and contextualized manner. Aligning with local needs and respecting the specificities of each audience are key to the success of these initiatives. In games about health or traditional cultures, incorporating values, terminology, and cultural references lends the game legitimacy. These findings highlight the importance of involving experts from various fields, such as health professionals, linguists, and community leaders, to validate game content and mechanics. Additionally, there is a need for teacher training strategies that empower educators to incorporate these resources into their teaching plans, thereby enriching the learning experience for students.

Some challenges are evident in the analyzed studies. The first of these concerns the sustainability of the projects, since many games are designed on an experimental basis and lack continuity and updates. In order for them to remain useful in the classroom or other educational environments, maintenance strategies and incremental updates are crucial. A second challenge relates to teacher training and technical support. Technologies may be accessible, but teachers often struggle to integrate them into the curriculum due to a lack of time or specific training. A third challenge relates to accessibility and inclusion. Although this issue is mentioned in some studies, it still needs to be addressed more effectively to accommodate different physical, cognitive, and cultural limitations. The fourth challenge is the ongoing assessment of engagement, as student motivation can fluctuate over time, requiring adjustments to the design of phases, scores, or narratives to avoid losing interest or underutilizing the training. Finally, interdisciplinary partnerships are needed, as the creation of mobile educational games requires collaboration between educators, designers, programmers, and other experts. Interdisciplinary teams tend to develop products that better meet the real needs of learners.

In addition to the operational and pedagogical challenges already listed, critical reflection on the ethical implications is fundamental to the field of mobile educational games. This SLM highlights the criticality of these issues by mapping the various application contexts and the often vulnerable target audiences, such as children and individuals with special needs (as detailed in Subsection 5.8). While this review's methodology did not prioritize extracting data on how primary studies explicitly address ethical protocols, analyzing the game contexts, technologies employed, and game mechanics suggests that collecting and processing user data is inherent to many of these applications. This highlights the urgent need for an in-depth ethical discussion.

In this sense, data ethics is particularly relevant, encompassing the transparent collection and safe use and appropriate storage of user information, which may include sensitive performance and interaction data. The UNESCO [2022] Recommendation on the Ethics of Artificial Intelligence (AI), for example, provides a robust framework emphasizing that data for AI systems should be collected and managed in a manner that is compatible with international law and ethical principles. It also highlights the need for data governance and quality assessment of training data. Another central point of the same Recommendation is the protection of children and young people in the context of AI, aiming to ensure that their rights are not violated and that their learning data is not used for commercial exploitation or other inappropriate purposes [UNESCO, 2022].

Defending the digital rights of children and adolescents is equally crucial, as demonstrated by the US Children's Online Privacy Protection Rule (COPPA). This regulation imposes clear requirements on operators of online services aimed at children. These include the need to notify parents, obtain verifiable parental consent for data collection, and implement procedures to protect the confidentiality, security, and integrity of this information. This information must only be retained for as long as is necessary. These international guidelines emphasize the importance of informed consent, transparency in the use of data, and protection against exploitative practices [Federal Trade Commission, 2013].

Additionally, the ethical dimension is integral to the issues of accessibility and inclusion, which have already been identified as challenges in this SLM. The UNESCO [2022] Recommendation reinforces this point by advocating the promotion of diversity and equitable access to the benefits of AI for all groups. In light of this, human-centered technological design that respects autonomy and promotes the well-being of learners is essential. The complexity and relevance of these ethical considerations, which are only touched upon by the primary studies analyzed in this review from other perspectives, indicate a fruitful and necessary path for further analysis. This could involve systematically investigating how mobile educational games incorporate such ethical principles in their development, use, and evaluation.

In short, this discussion has revealed the complexity involved in developing and applying effective and responsible mobile educational games. Overcoming the multiple challenges identified — ranging from technological and methodological choices and project sustainability to teacher training, accessibility, inclusion, and ethical implications — requires comprehensive strategies to be articulated. Therefore, advancing in this area requires integrating the development cycle with rigorous field research, providing continuous training for educators, and promoting interdisciplinary collaborations. The transformative potential of these pedagogical resources can be realized through careful methodological implementation, constant monitoring of their impact, and adherence to ethical principles.

7 Lessons Learned

Based on the personal motivation presented in Section 1 — to transform an informative application about quilombola culture into a more dynamic and playful educational game — this study sought elements and approaches that would guide the development of similar applications in the reviewed studies. The summaries of the research questions revealed some valuable insights, which are presented below as lessons learned and will serve as a foundation for the future development of a cultural educational game:

- **Development Technologies:** Unity is the most widely used game engine, alongside other tools such as Flutter and Android Studio, and programming languages such as C#, Java, and Dart. The choice of technology should consider the creation of interactive and immersive environments aligned with pedagogical objectives,
- **Development Methodologies:** Several methodologies are employed, including ADDIE, MDLC, Scrum, and User-Centered Design. The methodology selected must be compatible with the project's needs, from initial prototyping to formative evaluation,
- **Human-Computer Interaction (HCI:** Strategies to improve HCI involve using augmented reality for immersion, as well as tactile and holographic interfaces and multimodal elements to meet diverse needs. Accessibility and inclusion are crucial in interaction design,
- **Game Elements:** Narratives, challenges, rewards, progression, personalization, and feedback are frequently used elements. It is essential to integrate these elements coherently with the proposed educational objectives,
- **Engagement and Motivation:** Gamification, engaging narratives, challenges, personalization, and adaptation are key factors in engaging users. Mechanics such as scoring, rankings, and rewards encourage active and prolonged participation,
- **Adaptation for Different Users:** Mobile educational games can be adapted for different age groups and skill levels, including those with special needs. Personalization and customization ensure greater usefulness and effectiveness in the learning process,
- **Evaluation of Mobile Educational Games:** This involves quantitative and qualitative methods such as usability tests, software tests, direct observations, and experimental designs. Continuous evaluation and comparative studies are recommended to verify pedagogical impact and user engagement,
- **Game Mechanics:** The most common include quiz games, puzzle games, gesture/touch/motion control, word/matching games, RPGs, and simulations. The definition of these mechanics should consider the learning objectives and the profile of the target audience.

The main lesson learned from these findings is that developing an educational game focused on cultural themes, such as the Quilombola Culture App [Sales and Oliveira, 2023], requires the adoption of appropriate technologies and robust methodologies. It also requires active listening to the communities involved, consistent contextualization of cultural content, and motivational strategies to promote engagement among users of different age groups. This SLM therefore provides solid guidelines for designing a cultural and educational game, strengthening the personal and academic motivations that drove this work.

8 Threats to Validity

Although conducting an SLM involves several carefully planned steps, it is subject to methodological limitations. This section discusses the main threats to validity that were identified during this study. The aim is to recognize potential weaknesses and ensure greater transparency when presenting the obtained results:

- **Construct validity**: This concerns the adequacy of the instruments and procedures adopted to identify and analyze the publications. In this study, we established an SLM protocol based on Kitchenham and Charters [2007], defining the inclusion and exclusion criteria, the search databases, and the search strings. However, it is possible that the search strategy did not include relevant synonymous terms or variations, which could lead to the omission of some important studies. Additionally, some studies classified as 'irrelevant' during the title and abstract screening phase may have contained pertinent information, even if it was not highlighted in the abstract,
- **Internal validity**: This refers to possible biases and inconsistencies in the selection and data extraction procedures. There is a risk of individual reviewer bias during screening. To minimize this risk, all research actions were validated in advance with the advisor, who has extensive experience in the research topic and in executing SLM,
- **External validity**: This refers to the generalizability of the findings and their applicability to other contexts. Although we selected broad databases (Scopus, Web of Science, and IEEE Xplore) and adopted clear inclusion and exclusion criteria, some studies may not have been

indexed in these databases, or may have been published in languages other than English or Portuguese. Furthermore, our 5-year time frame and prioritization of full-length articles/papers may exclude older results or early-stage studies that could provide valuable insight. These choices were made to ensure a focus on recent studies with sufficient methodological detail; however, they limit the extrapolation of the results to the entire field of mobile educational games,

- **Conclusion validity**: This refers to the ability to draw correct conclusions based on the extracted data. A possible threat to this validity arises from the fact that not all selected studies fully answered all of the formulated research questions. In some cases, it was necessary to indicate that certain research questions had not been answered. This limitation may compromise the robustness of some interpretations, especially when comparing studies.

Despite these challenges, the established protocol is believed to have helped mitigate threats to the validity of the research, providing a consistent and reliable overview of the development of educational mobile games.

9 Conclusion

This SLM on mobile educational games enabled us to map and analyze the current panorama and recent trends (over the last five years) in this rapidly growing area. Throughout the study, we identified research trends, technologies, and methodologies, as well as different contexts for the application of mobile educational games. Additionally, the analysis revealed the potential of playful and interactive resources in promoting motivation, engagement, and meaningful learning among students, demonstrating the field's contribution to innovative and inclusive pedagogical practices.

In terms of contributions, this work provides an updated overview of the main approaches involving the design and use of mobile educational games. For the academic community, this SLM provides a structured knowledge base that can facilitate future research, highlighting gaps and suggesting new lines of investigation, especially with regard to personalization strategies and the evaluation of educational impact. The clear identification of the most widely used technologies and tools, as well as the methodologies, represents a valuable resource for researchers seeking to improve or develop new mobile educational games that contribute to the scientific community.

For teachers/professors, the contributions are associated with providing a solid reference on the benefits and challenges of using these games in the classroom, enabling more informed decisions to be made regarding the adoption of these technologies in everyday teaching practices. The presented systematization can also support teachers/professors in developing new didactic strategies, using mobile educational games to address specific learning needs and promote more inclusive and locally adapted education.

The contributions of this study are relevant for developers as they offer insights into best practices for creating mobile educational games. These include selecting appropriate technologies, taking effective approaches to improving human-computer interaction and using gamification mechanisms to maximize user engagement.

Among the study's limitations, we highlight the restricted databases and publication period. Although these were essential for making the study more manageable and focused, they may have excluded relevant research from other libraries and published at different times. Additionally, we only considered studies written in Portuguese or English, which may have excluded contributions in other languages. Another limiting factor is the diversity of contexts in which mobile educational games are used. While the set of analyzed studies is significant, educational and technological realities are heterogeneous, making it difficult to generalize the results broadly.

For future work, we recommend conducting a more in-depth qualitative analysis of the identified initiatives to better understand the impact of games on different age groups, disciplines, and cultural contexts. A promising line of research would be to study strategies for adapting and personalizing mobile educational games to specific learning needs, including those of groups with limited access to technology or requiring accessibility resources. Additionally, we recommend investigating the various gameplay characteristics that impact engagement and pedagogical effectiveness in different contexts and for different user profiles, subdividing them into gameplay and accessibility axes.

Another crucial area for future research is the systematic analysis of how ethical considerations, including the data privacy and digital rights of children and adolescents, are addressed (or neglected) when mobile educational games are developed, applied, and evaluated. Furthermore, longitudinal studies should be conducted to monitor the development of students' skills and competencies over extended periods through the practice of mobile educational games. Finally, future investigations should broaden the scope of research. One way to achieve this would be to conduct a review focused on the Brazilian context, including relevant national databases such as SOL. This would enable an in-depth analysis of the specificities of research and development in Brazil and a comparative study with the global trends identified here. Additionally, cost-effectiveness studies or those examining applications in more diverse socioeconomic contexts could be considered to support strategic decision-making in education.

In summary, despite the limitations of systematic mapping, the results obtained reinforce the relevance of mobile educational games as instruments combining technological innovation, playful engagement, and pedagogical potential. The growth trend in this area indicates the continued need for research delving deeper into aspects such as the impact on learning, the evaluation of long-term results, and the development of effective implementation methodologies. Thus, it is expected that this study will contribute to strengthening the scientific debate and inspiring the creation of even more inclusive, interactive, and relevant teaching proposals in the contemporary educational landscape.

Declarations

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Authors' Contributions

Jonathan José Cardoso de Sales: conceptualization, data curation, formal analysis, investigation, methodology, writing - original draft. Sandro Ronaldo Bezerra Oliveira: conceptualization, supervision, validation, writing - review and editing.

Competing Interests

The authors declare that they have no competing interests.

Availability of Data and Materials

The materials used in this research are available at the following link: https://zenodo.org/records/15256599. Accessed on 17 July 2025.

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Appendix

Table 5. Studies Corpus of Systematic Literature Mapping

ID	Reference
PS01	Trassi, Nathalia Souza and Belloni, Gabriel Gomes and Mattos, Natalia Gama and de Oliveira Brisotti, Vinicius and Silveira, Ismar Frango (2022). (Re) Learning fine motor hand movements with serious games. 2022 XVII Latin American Conference on Learning Technologies (LACLO).
PS02	Zhou, Heng Seng and Nugraha, Ryan Adhitya and Md Fudzee, Mohd Farhan and Othman, Muhammad Fakri and Syamsuar, Dedy and Ismail, Azizan and Witarsvah, Deden and Suparjoh, Suriawati and Nurhayati, Iis Kurnia and Sugiat, Maria Apsari (2022). 2D Mobile Vocab Library Learning Application. 2022 International Conference Advancement in Data Science, E-learning and Information Systems (ICADEIS).
PS03	Cayabyab, Gerald T. and Mendoza, Paula Jean C. and Mauricio, Keila Marie S. and Salo, Arceli F. and Santiago, Nila D. and Reyes, Kurt Russel D. Delos (2023). A 3D Board Game Using a Randomized Algorithm and AI to Improve English Vocabulary Retention and Fluency. 2023 IEEE 13th International Conference on System Engineering and Technology (ICSET).
PS04	Florensia, Jennie and Suryadibrata, Alethea (2023). 7-Day Math: A Mobile Visual Novel Game for Mathematics Education. International Journal of Interactive Mobile Technologies.
PS05	Sarasmita, Made Ary and Larasanty, Luh Putu Febryana and Kuo, Li-Na and Cheng, Kuei-Ju and Chen, Hsiang-Yin (2021). A Computer-Based Interactive Narrative and a Serious Game for Children With Asthma: Development and Content Validity Analysis. JOURNAL OF MEDICAL INTERNET RESEARCH.
PS06	Yahuarcani, Isaac Ocampo and Llaja, Lelis Antony Saravia and Satalaya, Angela Milagros Nuñez and Bitulas, Lucio Alberto Sosa and Gómez, Edgar Gutiérrez and Lagos, Kay Dennise Jeri and Cortegano, Carlos Alberto Garcia and Alcantara, Gianina Alejandra Matienzo and Atuncar, Giancarlo Sánchez and Pezo, Alejandro Reátegui and Cruzado, Javier Arturo Gamboa (2021). A digital educational tool for learning the Aymara language in the region of Ayacucho, Peru. 2021 IEEE World Conference on Engineering Education (EDUNINE).
PS07	Chaisriya, Kannattha and Gilbert, Lester and Suwangerd, Ratchada and Rattanarungrot, Sasithorn (2022). A digital game for preserving food cultural heritage: design and evaluation of ThaiFoodAdventure game. International Journal of Electrical and Computer Engineering.
PS08	Hsieh, Ching-Yu and Chen, Chih-Ming and Yang, Ya-Chu (2023). A Game-based Augmented Reality Navigation System to Support Makerspace User Education in a University Library. 2023 14th IIAI International Congress on Advanced Applied Informatics (IIAI-AAI).
PS09	Saksrisathaporn, Krittiya (2020). A gamebased learning approach to improve students ⇔ spelling in thai. International Journal of Advanced Computer Science and Applications.
PS10	Kariyawasam, Ruchira and Nadeeshani, Madhuka and Hamid, Tuan and Subasinghe, Inisha and Ratnayake, Pasangi (2019). A Gamified Approach for Screening and Intervention of Dyslexia, Dysgraphia and Dyscalculia. 2019 International Conference on Advancements in Computing (ICAC).
PS11	Nicolaidou, Iolie and Tozzi, Federica and Antoniades, Athos (2022). A gamified app on emotion recognition and anger management for pre-school children. International Journal of Child-Computer Interaction.
PS12	Patrício, J. M. and Costa, M. C. and Manso, A. (2019). A Gamified Mobile Augmented Reality System for the Teaching of Astronomical Concepts. 2019 14th Iberian Conference on Information Systems and Technologies (CISTI).
PS13	Leenaraj, Bhornchanit and Arayaphan, Watsaporn and Intawong, Kannikar and Puritat, Kitti (2023). A gamified mobile application for first-year student orientation to promote library services. JOURNAL OF LIBRARIANSHIP AND INFORMATION SCIENCE.
PS14	Cerezo, Rebeca and Calderon, Vicente and Romero, Cristobal (2019). A holographic mobile-based application for practicing pronunciation of basic English vocabulary for Spanish speaking children. INTERNATIONAL JOURNAL OF HUMAN-COMPUTER STUDIES.
PS15	Ortiz, Guadalupe and Garcia-de-Prado, Alfonso and Boubeta-Puig, Juan and Cwierz, Halina (2020). A Mobile Application as Didactic Material to Improve Learning on Distributed Architectures. 2020 International Conference on Computational Science and Computational Intelligence (CSCI).
PS16	Vepsalainen, Henna and Skaffari, Essi and Wojtkowska, Katarzyna and Barlinska, Julia and Kinnunen, Satu and Makkonen, Riikka and Heikkila, Maria and Lehtovirta, Mikko and Ray, Carola and Suhonen, Eira and Nevalainen, Jaakko and Sajaniemi, Nina and Erkkola, Maijaliisa (2022). A Mobile App to Increase Fruit and Vegetable Acceptance Among Finnishand Polish Preschoolers: Randomized Trial. JMIR MHEALTH AND UHEALTH.
PS17	Ronimus, Miia and Eklund, Kenneth and Westerholm, Jari and Ketonen, Ritva and Lyytinen, Heikki (2020). A mobile game as a support tool for children with severe difficulties in reading and spelling. JOURNAL OF COMPUTER ASSISTED LEARNING.

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PS127	Hassan, Saad and Hasib, Aiza and Shahid, Suleman and Asif, Sana and Khan, Arsalan (2019). Kahaniyan - Designing for acquisition of Urdu as a second language. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics).
PS128	Tangsripairoj, Songsri and Sukkhet, Mathawee and Sumanotham, Jidapa and Yusuk, Benya (2019). Kiddy Manner: A Game-Based Mobile Application for Children Learning Thai Social Etiquette. JCSSE 2019 - 16th International Joint Conference on Computer Science and Software Engineering: Knowledge Evolution Towards Singularity of Man-Machine Intelligence.
PS129	Chen, I-Chien and Rocha-Beverly, Christel and Schneider, Barbara (2022). Learning by playing Init2Winit: How alignment knowledge increases educational aspirations and college plans in high school. JOURNAL OF RESEARCH ON TECHNOLOGY IN EDUCATION.
PS130	Pombo, Nuno and Santos, Hermenegildo (2023). Lessons Learned from the Development of a Computerised Badge-based Reward Tool for Student Engagement in Learning Activities. 2023 IEEE World Engineering Education Conference (EDUNINE).
PS131	Estrada-Cota, Italia and Carreño-León, Mónica A. and Andrés Sandoval-Bringas, J. and Leyva-Carrillo, Amado Alejandro (2020). Manos que hablan: tool for teaching – learning the Mexican Sign Language for children with or without hearing disabilities. 2020 3rd International Conference of Inclusive Technology and Education (CONTIE).

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PS134	Fonseca, Custodia S. C. and Zacarias, Marielba and Figueiredo, Mauro (2021). MILAGE LEARN plus : A Mobile Learning App to Aid the Students in the Study of Organic Chemistry. JOURNAL OF CHEMICAL EDUCATION.
PS135	Yahuarcani, Isaac Ocampo and Llaja, Lelis Antony Saravia and Satalaya, Angela Milagros Nuñez and Pezo, Alejandro Reátegui and Salazar, Frank Michael Villacorta and Cruzado, Javier Gamboa and Rengifo, Jorge Armando Ayarza and Díaz, José Edgar García and Torres, Neyer Gutiérrez and Cortegano, Carlos Alberto García and Baneo, Donalia Ycahuate (2021). Mobile application for the dissemination, learning and revitalisation of the native Muniche language in the Peruvian Amazon, in the context of Covid-19. 2021 4th International Conference on Inclusive Technology and Education (CONTIE).
PS136	Subandi and Joniriadi and Syahidi, Aulia Akhrian and Mohamed, Amran (2020). Mobile Augmented Reality Application with Multi-Interaction for Learning Solutions on the Topic of Computer Network Devices (Effectiveness, Interface, and Experience Design). 2020 Third International Conference on Vocational Education and Electrical Engineering (ICVEE).
PS137	Andamari, Chalifa Sophie Anggit and Yong, Billy and Jie Lee, Ryani Yuan and Yanfi, Yanfi (2023). Mobile Educational Game 'Imuno' to Teach Human Immune System. Proceedings - 2023 6th International Conference on Computer and Informatics Engineering: AI Trust, Risk and Security Management (AI Trism), IC2IE 2023.
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PS141	Blattgerste, Jonas and Franssen, Jannik and Arztmann, Michaela and Pfeiffer, Thies (2022). Motivational benefits and usability of a handheld Augmented Reality game for anatomy learning. 2022 IEEE International Conference on Artificial Intelligence and Virtual Reality (AIVR).
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PS143	Rebollo, Cristina and Remolar, Inmaculada and Rossano, Veronica and Lanzilotti, Rosa (2022). Multimedia augmented reality game for learning math. Multimedia Tools and Applications.
PS144	Singh, Nishal and Nagowah, Leckraj (2021). OOP Codes: Teaching Object-Oriented Programming Concepts Through a Mobile Serious Game. 2021 25th International Computer Science and Engineering Conference (ICSEC).
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PS151	Santos, José Eduardo da Silva and Magalhães, Luís Gonzaga Mendes (2021). QuizHuntAR: A location-based Augmented Reality game for education. 2021 International Conference on Graphics and Interaction (ICGI).
PS152	Din, Suhaili and Ramli, Maisarah Mohd (2023). Ramadan Spirit: A Digital Game Incorporating Malaysian Culture to Teach Malaysian Muslim Children the Islamic Essence of Ramadan. 2023 17th International Conference on Ubiquitous Information Management and Communication (IMCOM).
PS153	Baranyi, René and Czech, Pawel and Walcher, Florian and Aigner, Christoph and Grechenig, Thomas (2019). Reha@Stroke - A Mobile Application to Support People Suffering from a Stroke Through Their Rehabilitation. 2019 IEEE 7th International Conference on Serious Games and Applications for Health (SeGAH).
PS154	Alexandre, Isabel Machado and Lopes, Pedro Faria and Borges, Cynthia (2023). Roadmap for the Development of EnLang4All: A Video Game for Learning English. MULTIMODAL TECHNOLOGIES AND INTERACTION.
PS155	Steinmaurer, Alexander and Pirker, Johanna and Gütl, Christian (2019). Scool - Game-based learning in computer science class A case study in secondary education. International Journal of Engineering Pedagogy.
PS156	Rinaldi, Robinardo Ekariski and Wihartono, Marco Thomas and Dharmalim, Ryan Eka and Suharjito (2022). Serious Game Application Development for Learning Battle of Surabaya. 9th International Conference on ICT for Smart Society: Recover Together, Recover Stronger and Smarter Smartization, Governance and Collaboration, ICISS 2022 - Proceeding.
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PS159	Seralidou, Eleni and Douligeris, Christos and Gotsiopoulos, Panagiotis (2019). Students' evaluation of the 'web technologies' android application for higher education. 2019 4th South-East Europe Design Automation, Computer Engineering, Computer Networks and Social Media Conference, SEEDA-CECNSM 2019.
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PS162	Chen, Chia-Chen and Huang, Po-Hao (2023). The effects of STEAM-based mobile learning on learning achievement and cognitive load. INTERACTIVE LEARNING ENVIRONMENTS.
PS163	Siregar, Faisal Ridwan and Sukmana, Yuda and Rosmansyah, Yusep (2023). The Influence of Gamification on Quran Reading Learning. 2023 10th International Conference on ICT for Smart Society (ICISS).
PS164	McCarthy, Danielle M. and Formella, Kyle T. and Ou, Eric Z. and Vozenilek, John A. and Cameron, Kenzie A. and Salzman, David H. and Doty, Amanda M. B. and Piserchia, Katherine and Papanagnou, Dimitrios and Rising, Kristin L. (2022). There's an app for that: Teaching residents to communicate diagnostic uncertainty through a mobile gaming application. PATIENT EDUCATION AND COUNSELING.
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PS166	Yahuarcani, Isaac Ocampo and Llaja, Lelis Antony Saravia and Satalaya, Angela Milagros Nuñez and Cruzado, Javier Arturo Gamboa and Moreno, Juan Gamarra and Díaz, Jose Edgar García and Gómez, Edgar Gutierrez and Salazar, Frank Michel Villacorta and Chavez, Rosario Del Aguila (2022). Ts□□mene: Mobile application to improve the knowledge and revitalisation of the Bora language in the context of COVID-19 in Loreto Peru. 2022 IEEE World Engineering Education Conference (EDUNINE).

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PS172	Norlev, Jannie and Derosche, Christina and Sondrup, Katrine and Hejlesen, Ole and Hangaard, Stine (2022). Using Distance Communication for the User-Centered Development of a Smartphone-Based Serious Game for Children With Type 1 Diabetes:Participatory Design Approach. JMIR SERIOUS GAMES.
PS173	Suyanta and Wiludjeng, Insih and Jumadi and Astuti, Sri Rejeki Dwi and Sari, Anggi Ristiyana Puspita and Isa, Illyas Md and Jafaar, Rosly and Rahadian (2022). Virtual Laboratory-Based Game Application: The Quality and Its Effects Towards Students' Motivation and Self-Regulated Learning. International Journal of Interactive Mobile Technologies.
PS174	Yahuarcani, Isaac Ocampo and Llaja, Lelis Antony Saravia and Satalaya, Angela Milagros Nuñez and Cruzado, Javier Arturo Gamboa and Acuña, Anthony Johan Alfaro and Díaz, Jose Edgar García and Gómez, Edgar Gutierrez and Rengifo, Jorge Armando Ayarza and Aguila, Rosario Del (2022). WAWA: Mobile educational tool for learning the Kichwa language for the communities of the Napo River in Loreto, Peru. 2022 IEEE World Engineering Education Conference (EDUNINE).
PS175	Liu, Sa and Grey, Brian and Gabriel, Mina (2023). Winning could mean success, yet losing doesn't mean failure"—Using a mobile serious game to facilitate science learning in middle school. Frontiers in Education.
PS176	Ruiz, Muel Fred L. and Esclada, Rica I. and Balderama, Jannica H. and Aguirre, Anzel Anne I. and Cutin, Ma Nancy I. and Lozada, Raymund M. (2021). WISE game: wireless interactive software educational game. Indonesian Journal of Electrical Engineering and Computer Science.

Table 6. Distribution of Studies by Game Elements

Game Elements	Studies	Percentage
Points / Score	PS01, PS02, PS04, PS09, PS12, PS13, PS14, PS18, PS21, PS25, PS28, PS30, PS41, PS44, PS45, PS47, PS51, PS52, PS53, PS54, PS55, PS56, PS57, PS58, PS59, PS62, PS63, PS64, PS65, PS67, PS68, PS69, PS70, PS73, PS74, PS75, PS77, PS78, PS79, PS80, PS82, PS83, PS84, PS85, PS86, PS87, PS88, PS91, PS92, PS93, PS94, PS95, PS96, PS99, PS101, PS105, PS107, PS108, PS109, PS111, PS112, PS113, PS114, PS115, PS116, PS117, PS118, PS119, PS121, PS122, PS123, PS125, PS126, PS127, PS128, PS129, PS130, PS131, PS132, PS133, PS134, PS137, PS138, PS141, PS142, PS143, PS148, PS149, PS152, PS154, PS155, PS157, PS158, PS159, PS160, PS162, PS163, PS165, PS167, PS169, PS170, PS171, PS172, PS176.	59.09%

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Game Elements	Studies	Percentage
Phases / Difficulty Levels	PS01, PS03, PS09, PS11, PS16, PS19, PS21, PS23, PS26, PS27, PS28, PS30, PS31, PS33, PS39, PS41, PS44, PS45, PS46, PS47, PS48, PS52, PS53, PS54, PS56, PS57, PS58, PS59, PS60, PS61, PS63, PS64, PS65, PS67, PS68, PS69, PS70, PS71, PS72, PS74, PS75, PS78, PS81, PS85, PS87, PS88, PS91, PS95, PS97, PS99, PS101, PS102, PS103, PS104, PS105, PS106, PS107, PS108, PS110, PS111, PS112, PS113, PS115, PS116, PS117, PS120, PS121, PS122, PS123, PS125, PS126, PS128, PS132, PS133, PS134, PS137, PS138, PS141, PS143, PS144, PS146, PS148, PS149, PS151, PS152, PS153, PS154, PS155, PS156, PS158, PS160, PS161, PS162, PS163, PS165, PS167, PS168, PS169, PS171, PS172, PS173, PS176.	57.95%
Rewards / Achievements	PS07, PS09, PS11, PS20, PS23, PS24, PS28, PS33, PS37, PS39, PS40, PS41, PS45, PS46, PS47, PS54, PS55, PS56, PS58, PS62, PS68, PS69, PS72, PS73, PS74, PS78, PS79, PS85, PS90, PS95, PS99, PS101, PS105, PS107, PS108, PS110, PS111, PS112, PS113, PS114, PS115, PS117, PS121, PS122, PS123, PS126, PS128, PS130, PS133, PS137, PS141, PS144, PS145, PS148, PS149, PS153, PS157, PS158, PS160, PS161, PS163, PS169, PS170, PS171, PS172.	37.5%
Tasks / Challenges	PS08, PS16, PS18, PS21, PS23, PS28, PS30, PS38, PS43, PS45, PS49, PS51, PS55, PS58, PS59, PS60, PS61, PS64, PS67, PS68, PS70, PS72, PS74, PS75, PS78, PS79, PS81, PS82, PS83, PS84, PS85, PS90, PS94, PS95, PS99, PS100, PS101, PS105, PS108, PS109, PS110, PS111, PS112, PS113, PS114, PS117, PS118, PS122, PS123, PS127, PS129, PS137, PS138, PS141, PS144, PS148, PS151, PS158, PS160, PS162, PS163, PS164, PS165, PS171, PS173.	36.93%
Feedback	PS01, PS05, PS10, PS11, PS14, PS22, PS23, PS35, PS37, PS40, PS44, PS46, PS50, PS51, PS53, PS56, PS59, PS60, PS64, PS65, PS66, PS70, PS76, PS77, PS83, PS85, PS88, PS92, PS97, PS98, PS101, PS104, PS108, PS109, PS111, PS114, PS116, PS117, PS118, PS119, PS139, PS140, PS143, PS144, PS145, PS146, PS148, PS150, PS154, PS157, PS158, PS159, PS160, PS161, PS162, PS164, PS165, PS166, PS167, PS168, PS171, PS174.	35.23%
Rankings / Leaderboard	PS03, PS13, PS35, PS55, PS57, PS60, PS62, PS63, PS68, PS76, PS79, PS85, PS87, PS88, PS89, PS94, PS100, PS101, PS102, PS107, PS108, PS110, PS112, PS113, PS114, PS116, PS118, PS128, PS130, PS134, PS137, PS144, PS148, PS158, PS163, PS164, PS165, PS171, PS172, PS176.	22.73%
Characters / Avatars	PS01, PS05, PS07, PS11, PS13, PS23, PS24, PS34, PS44, PS45, PS54, PS56, PS59, PS71, PS72, PS82, PS83, PS85, PS91, PS101, PS102, PS108, PS114, PS117, PS128, PS132, PS138, PS143, PS149, PS157, PS160, PS163, PS164, PS171, PS176.	22.16%
Time Pressure / Times	PS13, PS18, PS25, PS28, PS31, PS51, PS52, PS60, PS62, PS68, PS72, PS78, PS80, PS81, PS82, PS84, PS85, PS93, PS94, PS96, PS111, PS116, PS119, PS122, PS123, PS131, PS143, PS147, PS151, PS152, PS163.	17.61%
Progress Tracking	PS20, PS28, PS35, PS39, PS41, PS44, PS56, PS58, PS65, PS69, PS74, PS83, PS88, PS89, PS95, PS102, PS103, PS106, PS108, PS111, PS154, PS163, PS171.	13.07%
Social Interaction	PS21, PS51, PS63, PS73, PS80, PS94, PS101, PS116, PS118, PS146, PS147, PS161, PS163, PS167, PS169, PS171, PS172.	9.66%
Player Lives / Health	PS48, PS52, PS56, PS72, PS82, PS90, PS97, PS102, PS108, PS114, PS123, PS131, PS143, PS152, PS156, PS158, PS170.	9.66%
Collectibles / Items	PS07, PS08, PS32, PS38, PS42, PS72, PS99, PS100, PS114, PS119, PS145, PS150, PS156, PS157, PS169, PS176.	9.09%
Content Unlocks	PS19, PS20, PS22, PS46, PS58, PS60, PS65, PS74, PS98, PS103, PS118, PS126, PS127.	7.39%
In-Game Coins	PS21, PS62, PS72, PS90, PS102, PS108, PS113, PS144, PS149, PS155, PS163, PS172.	6.82%
Narrative / Story	PS04, PS05, PS43, PS47, PS49, PS85, PS127, PS146, PS161, PS167, PS169, PS175.	6.82%
Augmented Reality	PS08, PS12, PS36, PS37, PS38, PS43, PS94, PS96, PS119, PS140, PS151.	6.25%
Character / Avatar Customization	PS03, PS17, PS21, PS22, PS90, PS122, PS155, PS169, PS172.	5.11%

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Game Elements	Studies	Percentage
Tips / Clues	PS43, PS54, PS73, PS81, PS102, PS109.	3.41%
Exploration	PS59, PS84, PS91, PS94, PS157.	2.84%
Scenarios	PS23, PS48, PS66, PS82, PS83.	2.84%
Choices / Decision Making	PS04, PS13, PS22, PS35.	2.27%
Inventory	PS13, PS99, PS100, PS102.	2.27%
Store	PS72, PS102.	1.14%
Easter Eggs	PS20.	0.57%