Augmented Reality and Gamification in Education: A Systematic Literature Review of Research, Applications, and Empirical Studies

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Abstract: This study scrutinizes the existing literature regarding the use of augmented reality and gamification in education to establish its theoretical basis. A systematic literature review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was conducted. To provide complete and valid information, all types of related studies for all educational stages and subjects throughout the years were investigated. In total, 670 articles from 5 databases (Scopus, Web of Science, Google Scholar, IEEE, and ERIC) were examined. Based on the results, using augmented reality and gamification in education can yield several benefits for students, assist educators, improve the educational process, and facilitate the transition toward technology-enhanced learning when used in a student-centered manner, following proper educational approaches and strategies and taking students’ knowledge, interests, unique characteristics, and personality traits into consideration. Students demonstrated positive behavioral, attitudinal, and psychological changes and increased engagement, motivation, active participation, knowledge acquisition, focus, curiosity, interest, enjoyment, academic performance, and learning outcomes. Teachers also assessed them positively. Virtual rewards were crucial for improving learning motivation. The need to develop appropriate validation tools, design techniques, and theories was apparent. Finally, their potential to create collaborative and personalized learning experiences and to promote and enhance students’ cognitive and social–emotional development was evident.

Keywords: educational technology; augmented reality; gamification; education; technology-enhanced learning; extended reality; immersive technologies; digital games; 21st-century pedagogy; review

1. Introduction

Rapid technological advancements have drastically affected all aspects of life, including education. This fact has contributed to the development of the interdisciplinary field of educational technology, which has undoubtedly impacted the teaching and learning process, environments, approaches, and methods by integrating technological applications into the educational process [1]. The COVID-19 pandemic accelerated the integration of technologies into education [2,3].

Nowadays, students are digital natives as they have grown up in a digitalized world; as such, they can easily handle digital devices and media on a daily basis [4]. As access to information is instant from any place at any time, a student’s way of acquiring knowledge and becoming informed has changed significantly [5]. Moreover, students form their personality in the light of flexible communities while requiring social interactions and prompt responses, and pursuing to be directly connected [6]. As a result, students’ educational requirements have drastically shifted and so have their perspectives on what
they regard as effective learning. They are seeking meaningful and personalized learning based on experiences and more engaging learning environments, which will motivate them to participate and perform better [7]. Moreover, students prefer to be actively involved in the educational process and not simply be passive listeners and onlookers [8].

Furthermore, learning is more natural, meaningful, and efficient when it places student inquiries at its core, enhances 21st-century skills development of students, addresses social issues, and is used in conjunction with information and communication technologies (ICT) [9,10]. Therefore, when state-of-the-art technologies are at the forefront and are used to their fullest potential in a student-centered manner, they can address these issues by providing deeper and more meaningful learning [11]. In addition, with digital devices and emerging technologies being adopted in teaching and learning activities at a rapid pace [12], non-digital and ineffective learning and teaching tools are replaced, existing educational processes are amplified and new educational methods and approaches are offered [13].

Therefore, to provide high-quality education and meet students’ needs, technology-enhanced learning should be adopted. Nonetheless, emphasis should be put on students’ skills, knowledge, personality traits, interests, and preferences as well as on constantly motivating, encouraging, and engaging them [14]. Using augmented reality and gamification in the educational process can contribute toward improving the educational process and the development of 21st-century skills, which can be divided into intrapersonal, interpersonal, and cognitive competence domains, and are fundamental to the learning process [15]. Due to its immersive, interactive, and engaging nature, augmented reality can be applied in numerous subjects of all educational stages while yielding educational benefits and creating new learning opportunities and potentials [16,17]. Gamification positively affects the educational process as it helps integrate game mechanisms and elements into teaching and learning activities, which in turn provide students with more intriguing, motivating, and engaging experiences that have the potential to increase their academic performance [18,19].

Justification, Aims, and Research Questions

Aiming at addressing students’ new and upcoming needs and requirements, education is transforming by integrating new technologies and technological paradigms into its process more actively [20]. The COVID-19 pandemic has further demonstrated the significance of incorporating new technologies and applying new approaches in education and the need to alter conventional learning environments and activities [21]. The combinational use of augmented reality and gamification has the potential to help toward the realization of this transformation, while at the same time yielding several educational merits and opportunities. Moreover, augmented reality and gamification share common attributes and both intrigue and motivate students to participate more actively and perform better in educational activities.

Although there have been several studies that examined the use of augmented reality and gamification in education separately, little is known regarding how they can affect education when used in combination. Consequently, the aim of this study was to carry out a systematic literature review to scrutinize the existing knowledge and studies concerning the use of augmented reality and gamification in education to establish its theoretical basis. In that view, this systematic literature review examines all types of related studies for all educational stages and subjects throughout the years. To guide the research, the following research questions (RQ) have been designed:

1. RQ1: What are the benefits of combining and integrating augmented reality and gamification into the educational process?
2. RQ2: What is the distribution among empirical studies, proposal and prototype papers, as well as review, conceptual, and theoretical papers?
3. RQ3: In which countries have most related studies been carried out?
4. RQ4: What have been the main findings of the related studies regarding the use of augmented reality and gamification in education?
5. RQ5: At which educational stage is the use of augmented reality and gamification more commonly applied?
6. RQ6: What is the main focus of the studies regarding students’ cognitive and social–emotional development?
7. RQ7: What sample has mostly been used in the experiments of the related research?
8. RQ8: What have been the most relevant objectives and aims of the studies concerning the use of augmented reality and gamification in education?
9. RQ9: Which are the main areas, topics, and subjects the use of augmented reality and gamification is more widely studied and applied?
10. RQ10: What measurements (research instruments, tools, methods, and variables) are mostly used in the studies regarding the use of augmented reality and gamification in education?
11. RQ11: What development tools, methodologies, and operating systems are mostly used to develop educational augmented reality applications?
12. RQ12: What devices are mostly used to carry out augmented reality experiments?
13. RQ13: What gamification mechanisms and elements are mostly used in gamified educational augmented reality applications?
14. RQ14: What areas, topics, and subjects do the proposed applications, frameworks, methodologies, and models focus on?
15. RQ15: Do the main findings of the different types of studies (empirical studies, proposals, and prototype papers, as well as review, conceptual, and theoretical papers) examined lead to the same conclusions?

2. Augmented Reality in Education

Augmented reality aims at enhancing users’ physical environment as it is perceived through their senses by enriching it with virtual objects and data. Particularly, augmented reality uses technological applications of computer units to generate a mixed reality in which real and virtual objects co-exist in real-time [22–28]. Augmented reality constitutes a flexible and interactive technology that can be further enriched when combined with other novel technologies [29]. Furthermore, due to its ability to present interactive content to users and change their perceptions, augmented reality has greatly influenced several domains and the educational sector is no exception [30]. As it combines the real environment with digital information, augmented reality is able to develop new learning environments and experiences as well as promote an active and interrelated learning process. Augmented reality has a close relationship to education, e-learning, gamification, as well as human–computer interaction, and through their 3D model representation and animations can improve memory retention and motivation [31]. Augmented reality helps break the barriers of formal education and enhances and promotes high-quality education, anywhere and at any time [32]. These facts, in combination with the growing popularity [33] and effectiveness in both teaching and learning activities, have led to an annual increase in both the quality and quantity of studies regarding augmented reality in educational settings [34]. Recent systematic review, scientific mapping, and bibliometric studies have presented both the benefits that can be yielded when integrating augmented reality into educational settings in a student-centered manner and some of its drawbacks and limitations [27,35–40].

Through the immersive, enjoyable, and realistic learning experiences that augmented reality provides, learning environments that support and promote inclusive, collaborative, situated, autonomous, problem-based, and ubiquitous learning can be created [17,41–44]. Compared with traditional learning environments, immersive augmented reality environments can offer more interactive experiences [45] while also reducing the resources, money, and time spent [46]. Additionally, students find the overall experience more intriguing and enjoyable, and as they become more motivated and engaged in the learning activities, they participate more actively and willingly, and as a result, their learning achievements, academic performance, knowledge acquisition, long-term retention, as well as their cognitive development are improved [47–56]. As students become aware of and experience the benefits yielded
by being involved in augmented reality-learning environments, they develop more positive attitudes toward technology-enhanced learning and digital inclusion.

The benefits of augmented reality outweigh its current limitations, and as it helps break the barriers of formal education and enhances and promotes high-quality education, anywhere and at any time, augmented reality can be integrated into all educational stages while supporting both teachers and students at the same time [16,17,32,36,57–59]. Although it can help prepare the future specialists of the upcoming technological era by providing the appropriate and necessary training [60], to reap the educational benefits of augmented reality to the fullest, it is crucial to adopt the (appropriate for each case) pedagogical approaches [61]. As augmented reality is an interactive technology that is closely connected to the real world and is gradually moving toward maturity, it can be integrated into several learning subjects [62–64]. Some subjects that augmented reality has been successfully applied to are: science, technology, engineering, mathematics (STEM) education [65–67], geometry [68], physics [44], chemistry [64,69], astronomy [70], mathematics [50], medical and healthcare education [71–73], anatomy [74], art [48], sports and physical education [75,76], geography [77], music [78], natural science [49], environmental science [79], language learning [80,81], history and cultural heritage education [82,83], vocational education [84], etc.

3. Gamification in Education

As several game theories and design approaches heavily depend on the same psychological theoretical backgrounds as learning, the gamification of the educational process was inevitable [85]. Since its first emergence, gamification has grown into a flourishing multidisciplinary field with near-limitless applications [86]. Gamification is not related to play or playfulness but to games, gamefulness, gameful interactions, and designs and can be defined as the use of game design elements, properties, atoms, and aspects within non-game contexts to improve user experience (UX), as well as user motivation, empowerment, and engagement [87,88]. Hence, as gamification draws its inspiration from games and capitalizes on the various game elements that keep users engaged and engrossed to make the whole experience more intriguing, challenging, and enjoyable, it can have the same outcomes in different contexts and activities [89,90].

In the context of education, gamification uses game mechanics, thinking, and aesthetics to promote learning and active participation, attract students’ interest, and motivate them to perform better [91]. Several positive results have been reported, which highlight the potential of applying gamification in combination with both traditional and novel methodologies within educational settings to improve students’ overall learning experience, motivate and engage them, and develop desired behavior [92]. Additionally, gamification implements motivational affordances to bring about improved psychological and behavioral outcomes [93]. As a result, gamification enhances students’ learning achievements and academic performance, self-efficacy, and retention while concomitantly leading to positive behavioral and psychological changes, to a different extent, depending on the context and the characteristics of the students and the educational material, though [94–96].

Several recent systematic literature review, scientific mapping, meta-analysis, and bibliometric studies have examined the impact of gamification on education and have presented the benefits of applying gamification within educational settings as well as the drawbacks and the limitations that need to be addressed to reap the merits of gamification to the fullest [18,19,97–103]. Due to the effectiveness of its integration into teaching and learning activities within pedagogical contexts, gamification is regarded as a valid didactic method, which has the potential to be used in combination with several technologies and other learning methods and approaches [104,105]. Within educational contexts, gamification promotes friendly competition, rewards effort, motivates and engages students using game elements, which they are already familiar with [7]. Therefore, gamification has already been implemented and evaluated within several educational subjects, such as science, technology, engineering, art and mathematics (STEAM) [106,107], language learning [108,109], medical and healthcare education [110–112], anatomy [113], sports and
physical education [114,115], geometry [116], chemistry [117,118], physics [119], mathematics [120,121], astronomy [122], geography [123], environmental science [124,125], natural science [126], history and cultural heritage education [127,128], music [129], and vocational education [130].

4. Methodology

4.1. Research Design

In order to answer the above-mentioned research questions and meet the aims set, a systematic literature review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was carried out [131]. As the topic analyzed was specific and involved empirical studies, case studies, reviews, proposals, as well as theoretical papers, the systematic literature review was deemed as an appropriate approach and the PRISMA statement was selected due to its highly strict rules and standards as well as the fact that it is a well-established method that is successfully applied in various topics, including education, offering comprehensive insights [132–134].

In order for a scientifically rigorous study to be conducted, 5 databases and a thorough combination of keywords were used to identify the related documents. More specifically, the databases SCOPUS, Web of Science (WoS), IEEE, Google Scholar, and ERIC were used. It is worth noting that through SCOPUS and WoS databases, the largest number of related documents and the most accurate ones were retrieved. This fact is in line with them being regarded as high-impact scientific databases [135].

4.2. Systematic Literature Review Process

Data was retrieved in January 2022. With a view to covering all the literature around this specific topic throughout all the previous years, no year limitation was set. A pertinent and thorough search equation was used to report the literature on the state-of-the-art while addressing all educational stages and topics. Consequently, and due to the interdisciplinary nature of the topic, the following query using wildcards and logical operators was used: “(‘augmented reality’) AND (‘gamif*’) AND (‘education’ OR ‘universit*’ OR ‘college*’ OR ‘school*’ OR ‘student*’ OR ‘pupil*’ OR ‘teach*’ OR ‘learn*’)”. In SCOPUS, WoS, IEEE, and ERIC databases, the search involved the title, abstract, and keyword parameters, while in Google Scholar the “allintitle” operator was used along with the keywords in consecutive order (e.g., ‘augmented reality’ AND ‘gamification’ AND ‘education’; ‘augmented reality’ AND ‘gamification’ AND ‘university’, etc.).

The whole process, which is displayed in Figure 1, followed and abided by all the steps and guidelines of the PRISMA statement. Initially, 670 documents were reported in the 5 databases (314 in SCOPUS, 204 in WoS, 80 in IEEE, 53 in Google Scholar, and 19 in ERIC). Of these documents, 220 were duplicates and were not included. Hence, 450 documents were screened. The main inclusion criteria were the combinational use of augmented reality and gamification elements, the reference to the educational context, and the studies involving either an empirical study, the development of an educational application, a proposal or prototype, a systematic review, or theoretical contributions. In total, 316 documents did not meet the research criteria and were excluded from the study. All of the 134 documents that were sought for retrieval were successfully retrieved. Therefore, 134 documents were examined for eligibility. In addition, 21 studies were excluded as they did not meet the necessary research criteria. Consequently, 113 studies were included and analyzed in the review.
The 113 studies identified were divided into three categories; that is, (1) empirical studies (73 articles, pct. = 64.6%), (2) proposal and prototype papers (design-oriented without being applied in educational contexts) (27 articles, pct. = 23.9%), and (3) review, conceptual, and theoretical papers (13 articles, pct. = 11.5%) (RQ2). The review, conceptual, and theoretical papers were scrutinized and their main findings were identified. Regarding the proposal and prototype articles, suggestions, guidelines, practices, areas of focus, and findings were also examined and analyzed. The empirical studies were analyzed and compared according to the following variables:

1. Country in which the experiments were conducted;
2. Educational stage;
3. Focus area;
4. Developmental category;
5. Sample;
6. Main aims;
7. Research method;
8. Main variables;
9. Measurement—research instruments and tools;
10. Application name;
11. Application development methodology;
12. Development tools;
13. Operating system;
14. Devices used in the experiment;
15. Gamification elements;
16. Main findings.
5. Results

A mixed-method research approach was adopted as both qualitative analysis and descriptive quantitative analysis were used to analyze the data [136]. The results acquired from the analysis of the articles and their variables from all three categories are presented below. Particularly, the results are categorized as those concerning the empirical studies (general information, research methods, variables and tools, application development information, and gamification elements, as well as main findings) in Tables 1–4, the proposal and prototype papers (general information, country, and aims) in Table 5 and the review, conceptual and theoretical papers (general information, aims, and main findings) in Table 6.

Table 1. Empirical studies: general information.

| Ref. | Country     | Educ. Stages          | Focus Area          | Develop. Category | Sample                                | Aims                                                                 |
|------|-------------|-----------------------|---------------------|-------------------|---------------------------------------|----------------------------------------------------------------------|
| [81] | Canada      | Higher education      | Language learning   | Cognitive         | 11 first-year higher school students  | To assess the potential of a mobile application that uses augmented reality and gamification to bridge the gap between education and gaming. |
| [137]| Spain       | n/a                   | Music               | Cognitive         | 5 teachers and 13 students from a musical school | To break the initial curve of learning music by motivating students and facilitating the learning process through an augmented reality application. |
| [138]| Indonesia   | Primary education     | Art                 | Cognitive         | n/a                                   | To create an augmented reality application to introduce batik design as a form of cultural art to primary school students. |
| [139]| Indonesia   | Primary education     | Culture             | Cognitive         | Primary school students and teachers | To develop an application that uses augmented reality and gamification and to analyze its impact on primary school students’ knowledge of Indonesian culture learning. |
| [140]| Malaysia    | Primary education     | Science             | Cognitive         | 9 primary school students and 1 teacher | To design and develop an augmented reality application that utilizes gamification elements to improve primary school students’ knowledge of microorganisms. |
| [141]| Peru        | Primary education     | Mathematics         | Cognitive         | 21 sixth-grade primary school students | To assess the impact of gamification and augmented reality on motivating primary school students to learn mathematics. |
| [142]| Brazil      | Primary education     | Association of images with words | Cognitive | 2 students | To gamify a crucial clinic activity for children on the autistic spectrum, namely the correlation of words with images. |
| [143]| Romania     | Higher education      | Medical education   | Cognitive         | 9 university medical students         | To promote self-learning, increase the learning desire, and facilitate the identification of skin-related medical conditions. |
| [144]| Spain       | Primary education     | Emotion detection   | Cognitive         | 38 fifth-grade primary school students | To compare the impact that competitive and collaborative gameplay styles have on students’ communication and motivation. |
| [145]| Taiwan      | Secondary education   | Health education    | Cognitive         | 52 senior high school students        | To design an educational augmented reality board game that capitalizes on card games, slides, and learning sheets to promote health education and compare its influence on students’ different emotions. |
| [146]| Hong Kong   | Higher education      | History and culture | Cognitive         | 35 university students               | To present preliminary results regarding the use of an augmented reality application with gamification elements to improve students’ educational experiences when learning history and culture during field trips. |
| [147]| Korea       | Higher education      | Language learning   | Cognitive         | 40 college students                  | To look into the way technology facilitates language learning and how students use the physical properties and context of a digital learning environment. |
Table 1. Cont.

| Ref. | Country      | Educ. Stages  | Focus Area   | Develop. Category | Sample                                      | Aims                                                                 |
|------|--------------|---------------|--------------|-------------------|---------------------------------------------|-----------------------------------------------------------------------|
| [148]| Taiwan       | Secondary education | Health education | Cognitive         | 52 high school students                      | To discuss the effectiveness of integrating augmented reality into board games to increase learning motivation and acceptance. |
| [149]| Portugal     | Higher education | Culinary         | Cognitive         | n/a                                         | To present the benefits of using gamification and immersive technologies in the learning process to motivate self-learning and continuous improvement. |
| [150]| Malaysia     | Primary education | Science        | Cognitive         | 20 public primary school students           | To investigate the impact of utilizing augmented reality on students’ learning of the solar system. |
| [151]| Canada       | Higher education | Language learning (French) | Cognitive | 58 university students                       | To analyze students’ viewpoints regarding their learning experiences and their collaboration in immersive learning environments. |
| [152]| Greece       | Primary education | Language learning (English) | Cognitive | 20 first-grade primary school students     | To investigate how augmented reality and gamified activities can enrich students’ vocabulary in foreign language learning. |
| [153]| Brazil       | Secondary education | Entomology     | Cognitive         | 21 middle school students                   | To examine how gamified augmented reality experiences impact students’ comprehension of entomological nomenclature and concepts and the development of skills that make them more focused on details. |
| [154]| Spain        | Primary education | Mathematics    | Cognitive         | 37 primary school students                  | To showcase that gamified augmented reality applications can make multiplication table learning more enjoyable and less monotonous for primary school students. |
| [155]| Japan        | Higher education | Language learning (Japanese) | Cognitive | 18 university students                       | To examine how using gamification and augmented reality can affect beginner language learners of Japanese and assist them in preparing for disastrous encounters. |
| [156]| Hong Kong    | Higher education | Chemistry     | Cognitive         | 46 university students with 37 valid responses | Showcase the potential of using augmented reality along with gamification to support Chemistry learning in flipped classrooms. |
| [157]| Greece       | Primary education | Language learning (Greek) | Cognitive | Primary school teachers and students       | To utilize a game-based learning and augmented reality approach to raise students’ awareness regarding recycling and COVID-19 and simultaneously enhance their related to the topic vocabulary. |
| [158]| Greece       | Primary education | Computer science (Programming) | Cognitive | 15 primary school students                  | To examine whether primary school students could understand the concept of intelligent environments and their programmable features through a gamified augmented reality application. |
| [159]| Spain        | Higher education | Computer science (Distributed architectures) | Cognitive | University students                        | To create a fun and playful experience to motivate students to review their acquired knowledge on given subjects through an augmented reality serious game. |
| [160]| Sri Lanka    | Higher education | Biology         | n/a               | n/a                                         | To introduce an augmented reality application that utilizes real-time image processing and recognition to support Biology learning. |
| [161]| China        | Higher education | Language learning (English) | Cognitive | 50 vocational college students              | To study how gamified augmented reality learning experiences can affect students’ learning motivation and collaboration in English courses. |
| [162]| United Kingdom | Secondary education | Geometry | Cognitive         | 120 middle school students                  | To analyze the motivational effects that various gamification elements have on educational augmented reality applications. |
| Ref. | Country     | Educ. Stages | Focus Area               | Develop. Category | Sample                                                                 | Aims                                                                                           |
|------|-------------|--------------|--------------------------|------------------|------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|
| [163]| Germany     | K-12 education | Culture and language learning | n/a              | 6 participants (university students and/or professionals)               | To showcase how augmented reality combined with gamification and machine learning can create immersive and interactive learning experiences for K-12 students. |
| [164]| Brazil      | Higher education | Anatomy                | Cognitive        | 91 university students (41 Bachelor, 34 Master, 16 Ph.D.)             | To present and evaluate an augmented reality application that uses game concepts to facilitate bone anatomy learning. |
| [165]| Australia   | Higher education | Computer science (Cybersecurity) | Cognitive | 5 college students, 5 English teachers, 5 technicians                  | To develop and present a game design that uses an augmented reality application to motivate students to be more aware and cautious of cybersecurity attacks. |
| [166]| China       | Higher education | Language learning (English) | Cognitive        | 5 college students, 5 English teachers, 5 technicians                  | To assess students’ acceptance levels of integrating an augmented reality application that uses gamification elements in English language learning. |
| [167]| Germany     | Higher education | Environmental engineering | Cognitive        | 19 university students                                                 | To assess the impact of a location-based augmented reality application, which uses game mechanisms on university students’ learning about environmental engineering. |
| [168]| Greece      | Primary education | Computer science (Programming) | Cognitive | Primary school students                                               | To examine whether primary school students find gamified augmented reality applications enjoyable and if they help them create rules to overcome learning problems. |
| [169]| Spain       | Higher education | Chemical Engineering    | Cognitive        | 179 university students throughout a period of 4 years                | To showcase how the use of gamification elements and augmented reality can support and improve students’ learning and comprehension of diverse topics while also increasing their academic results. |
| [170]| Spain       | K-12 education | Computer science (Programming) | Cognitive        | 12 primary school students                                             | To present an easy-to-use gamified augmented reality application that supports students’ knowledge acquisition while increasing their computational thinking and motivation. |
| [171,172]| Portugal | Higher education | General knowledge   | Cognitive        | 212 university professors (80 from S. Europe, 61 from S. America, and 71 from Asia) | To investigate how higher education professors in southern Europe, South America, and Asia view the use of mobile technologies and particularly the use of augmented reality and gamification applications within education. |
| [173]| Taiwan      | Secondary education | ATM skills         | Cognitive        | 3 junior high school students                                         | To increase ATM skills in students with intellectual disabilities.                               |
| [174]| Portugal    | Primary education | Astronomy            | Cognitive        | 90 primary school students and teachers                               | To showcase an educational augmented reality game, which aims at raising students’ awareness of astronomy concepts and promoting their learning regarding the planetary systems in formal and informal learning environments. |
| [175]| Greece      | Primary education | Computational thinking | Cognitive        | 26 primary school students                                             | To showcase a collaborative mobile augmented reality application that implements game elements to assist primary school students in developing their critical thinking skills. |
| [176]| Taiwan      | Secondary education | Language learning (English) | Cognitive        | 65 junior high school students                                       | To examine how iMap-enhanced and AR-enhanced learning within a gamified language learning context affects low achievers’ learning attitudes and performance. |
| Ref. | Country        | Educ. Stages | Focus Area                  | Develop. Category | Sample details                                                                 | Aims                                                                                                                                 |
|------|----------------|--------------|-----------------------------|-------------------|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|
| [177] | Thailand       | Higher education | Digital literacy           | Cognitive         | 197 university students (1st experiment) and 80 university students (2nd experiment) | To create interactive augmented reality experiences using gamification elements to influence learners’ digital literacy skills, learning achievements, and satisfaction, and to compare their results with those that follow conventional teaching methods. |
| [178] | Malaysia       | Primary education | Language learning (Tajweed) | Cognitive and social–emotional | 198 primary school students                                                   | To compare the impact of using gamification and augmented reality in Tajweed learning with other novel approaches.                  |
| [179] | New Zealand    | Higher education | Music                      | Cognitive         | 23 university students                                                        | To analyze the potential of implementing gamified augmented reality applications in music education.                                |
| [180] | China          | Higher education | Environmental education    | Cognitive         | 98 first-year university students                                              | To assess the influence of leveraging mobile augmented reality and gamification in environmental education and comprehend what university students think of this approach. |
| [181] | Thailand       | Higher education | STEAM                      | Social–emotional   | 138 first-year university students                                              | To enhance students’ grit using an augmented reality application and compare their grit scores with their learning achievements to comprehend their relationship. |
| [182] | Taiwan         | K-12 education | STEM                       | Social–emotional   | 177 students                                                                  | To analyze and comprehend the behavioral intentions of users that utilize the GAR-STEM teaching application.                          |
| [183] | China          | Higher education | Language learning (Chinese) | Cognitive         | 76 sophomore university students                                               | To describe how a mobile-augmented reality sandbox game can affect learning students’ Chinese characters learning.                  |
| [184] | United States  | Higher education | Spatial ability            | Cognitive         | 56 freshman university students                                                | To evaluate the impact of an augmented reality application on students’ performance and compare the results with those of students who followed conventional educational processes. |
| [185] | Colombia       | Primary education | Language learning (English) | Cognitive         | 163 primary school students                                                    | To present how integrating augmented reality through gamification into education can offer better learning results.               |
| [186] | United Arab Emirates | Primary education | Learning to write          | Cognitive         | Primary school students                                                        | To suggest an augmented reality system that facilitates students’ learning by allowing them to learn at their own pace, encouraging the involvement of their parents in it, and presenting instantaneous feedback. |
| [187] | Portugal       | Primary education | Astronomy                  | Cognitive         | Four groups of primary school students                                         | To showcase the results of a preliminary study involving a mobile augmented reality astronomy game that takes place in an informal learning context and supports students’ knowledge acquisition. |
| [188] | Italy          | Secondary education | Astronomy                  | Cognitive         | 14 secondary school students                                                   | To present a tool and methodology for creating augmented reality geo-localized learning activities and evaluate its effectiveness based on students’ viewpoints. |
| [189] | Malaysia       | Higher education | Language learning           | Cognitive         | 66 university students                                                         | To comprehend students’ viewpoints regarding the use of augmented reality and gamification in creating exciting learning experiences that promote active and collaborative learning. |
| [190] | United Kingdom | Primary education | Asthma care education      | Cognitive         | 18 primary school students                                                     | To propose a mobile augmented reality application that uses game elements to assist students’ self-management in asthma education. |
| Ref. | Country         | Educ. Stages | Focus Area               | Develop. Category | Sample                   | Aims                                                                                           |
|------|----------------|--------------|--------------------------|-------------------|--------------------------|------------------------------------------------------------------------------------------------|
| [191]| Germany        | n/a          | Language learning (Japanese kanji) | Cognitive         | 13 students              | To train students in all aspects of Kanji by capitalizing on the concept of flow to immerse students in a rich Japanese mythology game, which takes place in an augmented reality environment. |
| [192]| Malaysia       | Higher education | Architecture           | Cognitive         | 87 university students  | To investigate how instructional design can assist in developing mobile augmented reality applications that create enjoyable learning environments, which promote students’ active participation. |
| [193]| Argentina      | n/a          | General knowledge       | Cognitive         | 50 secondary and higher education students | To propose a framework for designing augmented reality applications and validating it by creating and assessing an application using the specific framework on a goose board game to reinforce the learning of concepts presented in a traditional classroom. |
| [194]| United Arab Emirates | Primary education | Learning to write | Cognitive         | Primary school students | To propose an augmented reality application that supports students by enabling them to learn at their own pace and to actively involve their parents. |
| [195]| Ukraine        | Secondary education | Physics and English   | Cognitive         | Four groups of secondary school students | To showcase the potential of using gaming elements and augmented reality to support the conduct of binary lessons, such as Physics and English, in secondary education. |
| [196]| Portugal       | K-12 education | Interdisciplinary themes | Cognitive         | 24 K-12 education students and 46 higher education ones | To analyze students’ perception of the gamified augmented reality application regarding its usability and learning values, and to comprehend their viewpoints. |
| [197]| China          | Higher education | Computer science (Web design) | Cognitive         | 221 university students | To present the benefits of using gamification and augmented reality to create personalized learning experiences in a classroom. |
| [198]| Thailand       | Higher education | Teamwork                | n/a               | 5 specialists selected by purposive sampling | To create an augmented reality application that promotes and increases students’ teamwork and to evaluate its effectiveness. |
| [199]| Egypt          | K-12 education | Mathematics             | Cognitive         | 18 diagnosed Down syndrome teenagers | To present an interactive AR-based game as an instructional means for Down syndrome teenagers. |
| [200]| Indonesia      | Secondary education | Language learning (French) | Cognitive         | 60 secondary school students | To create a gamified mobile learning system using augmented reality to improve French language learning. |
| [201]| Portugal       | Higher education | Teaching and learning process | n/a               | 37 university professors | To examine university professors’ viewpoints regarding the use of mobile learning when combined with augmented reality and gamification to improve students’ learning motivation. |
| [202]| Portugal       | K-12 education | Interdisciplinary themes | Cognitive         | 74 primary and secondary school students | To design, develop, and evaluate an augmented reality game to promote students’ learning in smart urban parks. |
| [203]| United States  | Higher education | Language learning (English) | Cognitive         | 3 university students | To improve students’ cultural understanding, language development, and communication skills through an augmented reality mobile game. |
| [204]| United States  | Secondary education | Engineering            | Cognitive         | 20 high school students | To present the design process of an augmented reality gamified learning experience and assess its impact on creating sustainable learning opportunities by increasing university students’ sensory capacities. |
| Ref. | Country     | Educ. Stages      | Focus Area         | Develop. Category | Sample                      | Aims                                                                 |
|------|-------------|-------------------|--------------------|-------------------|-----------------------------|----------------------------------------------------------------------|
| [205]| United States | K-12 education   | Mathematics        | Cognitive         | 5 primary school teachers   | To find and showcase the benefits and challenges of personalized gamified augmented reality experiences in K-12 education. |
| [206]| Cyprus      | Higher education  | General knowledge  | n/a               | 97 undergraduate university students | To examine the impact of augmented reality in learning in a classroom based on students’ perceptions. |
| [207]| Taiwan      | Secondary education | Chemistry        | Cognitive         | 152 high school students    | To investigate the impact of different augmented reality types and guiding strategies on high school students’ learning performance and motivation when studying electrochemistry concepts. |
| [208]| Malaysia    | n/a               | General knowledge  | Cognitive         | 150 participants             | To investigate the potential of using augmented reality games to support the development of learning through games. |

### Table 2. Empirical studies: research methods, variables, and tools.

| Ref. | Research Method | Main Variables                                                                 | Measurement Tools—Research Tools                                                                                             |
|------|-----------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| [81] | Mixed           | Participants’ assessments, learning experience, and evaluation of the application playability | Ad hoc pre-questionnaire and post-questionnaire, focus groups interviews, audio and video recordings, and data and statistics collection through the ARIS engine |
| [137]| Quantitative    | Students’ and teachers’ viewpoints regarding the perceived ease of use, levels of agreement, and usefulness | Ad hoc Likert scale survey following the Technology Acceptance Model (TAM) [209]                                               |
| [138]| Quantitative    | Media validation                                                             | Ad hoc survey                                                                                                               |
| [139]| Quantitative    | Systems usability and students’ knowledge acquisition                        | Black box tests, ad hoc questionnaire regarding teachers’ judgment and students’ usability assessment                         |
| [140]| Quantitative    | Usability and effectiveness                                                  | 10-item questionnaire presented in [210]                                                                                     |
| [141]| Quantitative    | Students’ comprehension of spatial geometry                                  | Pre-test and post-test questions regarding spatial geometry                                                                   |
| [142]| Quantitative    | Students’ ability to link words with images                                  | Ad hoc questionnaire                                                                                                          |
| [143]| Quantitative    | Students’ viewpoints                                                          | Ad hoc Likert scale survey                                                                                                   |
| [144]| Quantitative    | Students’ viewpoints and observers’ assessment                               | Ad hoc questionnaire, 7 items regarding game mode evaluation, 5 items about observations, and 9 items regarding communication and collaboration |
| [145]| Quantitative    | Students’ learning effectiveness, emotions, and flow experience              | 3 questionnaires, a 56-item ad hoc questionnaire with pre- and post-learning performance scale, the Achievement Emotions Questionnaire (AEQ) [211], and the Flow Experience Questionnaire designed by [212], as well as the Chinese version designed by [213] |
| [146]| Qualitative     | Students’ perspectives                                                       | Open-ended questions                                                                                                          |
| [147]| Qualitative     | How the application promotes meaningful language learning and how students use place mechanisms within it | Students’ learning outcomes assessment, post-surveys, and reflections, as well as qualitative data regarding application logs and open-ended questions |
| [148]| Quantitative    | Students’ acceptance level and learning motivation                           | The Instructional Material Motivation Survey (IMMS) [214] and the Technology Acceptance Model (TAM) [215]                      |
| Ref. | Research Method | Main Variables | Measurement Tools—Research Tools |
|------|----------------|----------------|----------------------------------|
| [149] | Quantitative | Control, sensory, distraction, and realism factors of the overall experience | The Presence Questionnaire [216] |
| [150] | Quantitative | Students’ pre-test and post-test scores | 3 ad hoc pre-test and post-test quizzes, one for each class |
| [151] | Mixed | Time on task, engagement, and collaborative learning | Pre-play and post-play questionnaires, interviews, and video recordings |
| [152] | Mixed | Retention rate, communication and interaction, learners’ attitudes, and overall effect on the educational process | Post-test, teachers’/researchers’ journals, and semi-structured interviews |
| [153] | Quantitative | Students’ knowledge of entomological terms and concepts | Multiple-choice learning tests adapted from the History Word Association Test (HWAT) [217] |
| [154] | Quantitative | Learning effectiveness and usability | Ad hoc pre-test and post-test questionnaires |
| [155] | Quantitative | The impact of gamified augmented reality application on beginner language learners | Ad hoc survey with open-ended questions |
| [156] | Quantitative | Students’ attitudes | 26-item questionnaire [64] |
| [157] | Qualitative | Vocabulary development, students’ active participation, and topic awareness | Interviews with open-ended questions and observations |
| [158] | Mixed | Students’ comprehension of intelligent environments | Open-ended questions, pre-test, post-test, and observations |
| [159] | Quantitative | Students’ viewpoints | Ad hoc questionnaire |
| [160] | Quantitative | Image detection model accuracy | Cross-validation |
| [161] | Qualitative | The impact of gamified augmented reality on learning motivation and collaboration | Interviews |
| [162] | Quantitative | Effects of different gamification mechanisms on learning experiences in augmented reality learning applications | Ad hoc 3-item questionnaire, measuring interest, confidence, and intention |
| [163] | Quantitative | Deep learning model performance | 3-part questionnaire, including demographic information, user experience, and information comprehension |
| [164] | Quantitative | System usability and learning aspects | Two ad hoc questionnaires regarding the systems interface, interactions, and learning aspects |
| [165] | Quantitative | Students’ viewpoints | 7-item ad hoc questionnaire |
| [166] | Quantitative | Users’ acceptance and application performance | Ad hoc questionnaire to evaluate the performance and acceptance of the application following the suggestions made by [218] |
| [167] | Qualitative | Students’ viewpoints, motivation, attitudes, and learning-related outcomes | Ad hoc questionnaire, observations, protocols, and guided interviews |
| [168] | Qualitative | Students’ errors made, interactions and hints used for each task | Observations |
| [169] | Quantitative | 4-year academic results in the form of grades and overall module completion rate | Academic performance assessment |
| Ref. | Research Method | Main Variables | Measurement Tools—Research Tools |
|------|-----------------|----------------|-----------------------------------|
| [170] | Mixed | Students’ motivation and interest in programming and their perceptions regarding the usefulness, intention, and usability of the augmented reality application | Ad hoc questionnaire inspired by the Technology Acceptance Model (TAM) [209] and open-ended questions |
| [171,172] | Quantitative | Professors’ viewpoints | 41-item online ad hoc questionnaire about students’ demographic information, prior knowledge, engagement, use of mobile devices in the classroom, and self-efficacy |
| [173] | Mixed | Number of independently completed tasks when using the ATM | Datasheets, observations, and video recordings |
| [174] | Mixed | Students’ and teachers’ viewpoints | Ad hoc questionnaire, open-ended questions, and observations |
| [175] | Mixed | Overall collaboration, enjoyment, interactivity, and comprehensibility | Ad hoc 4-item questionnaire, think-aloud feedback, observations, and performance recordings |
| [176] | Quantitative | Students’ learning performance and attitude | Ad hoc questionnaire regarding students’ attitudes as well as an achievement test |
| [177] | Quantitative | Students’ learning achievements, digital literacy skills development, and satisfaction | Ad hoc 20-item subjective test, rubric scoring based on the Likert scale [219] |
| [178] | Quantitative | Students’ emotional engagement and learning performance | Pre-test and post-test during design sessions and ad hoc questionnaire adopted from [220,221] |
| [179] | Mixed | Students’ viewpoints and system usability | Recorded comments and feedback and the System Usability Scale (SUS) [222] |
| [180] | Mixed | Students’ perceived usefulness, ease of use, attitudes, and behavioral intentions | Observations, interviews, and ad hoc survey with questions adopted from [215,223,224] |
| [181] | Quantitative | Students’ learning grit | Self-evaluation pre-tests and post-tests regarding students’ grit using scoring rubrics |
| [182] | Quantitative | Media interactivity, entertainment, practicability, attitude, and behavioral intention | Ad hoc questionnaire |
| [183] | Quantitative | Students’ learning style, learning interest, interactivity, and immersion | Ad hoc questionnaire |
| [184] | Mixed | Factors that affect students’ spatial reasoning performance when using the augmented reality application | Pre-test and post-test, data collection through the application, and ad hoc survey based on Intrinsic Motivation Inventory (IMI) [225] |
| [185] | Quantitative | Students’ ability to learn the numbers in English | Diagnosis and final verbal tests following a traditional grading system |
| [186] | Quantitative | Students’ ability to write the English letters | Ad hoc verbal tests |
| [187] | Qualitative | Students’ viewpoints | Ad hoc survey |
| [188] | Qualitative | Students’ viewpoints regarding the support that the tool provides in learning activities | Ad hoc questionnaire |
| [189] | Qualitative | Students’ perceptions | Ad hoc online survey and open-ended questions |
| [190] | Quantitative | Students’ knowledge | Ad hoc multiple-choice quiz |
| [191] | Quantitative | Students’ knowledge of Japanese language | Pre-test and post-test ad hoc questionnaire |
### Table 2. Cont.

| Ref. | Research Method | Main Variables | Measurement Tools—Research Tools |
|------|-----------------|----------------|----------------------------------|
| [192] | Mixed | Students’ viewpoints and insights | Ad hoc questionnaire |
| [193] | Quantitative | Students’ knowledge retention | 20 question quiz |
| [194] | Quantitative | Students’ ability to write the English letters | Ad hoc survey |
| [195] | Qualitative | Students’ evaluation of the use of gamified augmented reality in binary lessons | Observations |
| [196] | Mixed | Learning value and usability | System Usability Scale (SUS) [222], interviews, and usage data of the application |
| [197] | Quantitative | Students’ engagement, learning outcomes, task completion rate, and final grade | Collection of quantitative data from the final grade and the overall learning path during the experiment |
| [198] | Qualitative | Specialists’ inputs and opinions | Observations and scoring rubric |
| [199] | Quantitative | Learning gains, outcomes, control and joy | 9-item questionnaire adopted from [226] |
| [200] | Quantitative | Students’ motivation and learning results | Pre-test and post-test ad hoc questionnaires |
| [201] | Quantitative | Higher education professors’ viewpoints | Ad hoc questionnaire regarding students’ demographic information, prior knowledge, engagement, and use of mobile devices within the classroom |
| [202] | Qualitative | Students’ viewpoints and perception of joy | Observation reports and transcripts |
| [203] | Qualitative | Students’ viewpoints | Video recordings and interviews |
| [204] | Mixed | Learners’ engagement and the application functionality and features | Game analytics, video recordings, and photographs of learners, artifacts, and pre- and post-assessment |
| [205] | Qualitative | Teachers’ viewpoints | Interviews |
| [206] | Quantitative | Students’ opinions | 16-item ad hoc questionnaire |
| [207] | Quantitative | The effect of different augmented reality and guiding strategy types on learning performance and motivation | Prior knowledge test, performance test, and ad hoc questionnaire adapted from the Motivated Strategies for Learning Questionnaire (MSLQ) [227] |
| [208] | Quantitative | Main factors that motivate participants to play and urge them to continue playing | Ad hoc survey |

### Table 3. Empirical studies: Application development information and gamification elements.

| Ref. | Application Name | Development Tools | Operating System | Device | Gamification Elements |
|------|------------------|-------------------|------------------|--------|-----------------------|
| [81] | Explorez | ARIS | iOS | Mobile devices | Game-like features, badges, and quests |
| [137] | HoloMusic XP | Vuforia | Windows Holographic OS | Microsoft HoloLens | Scores and points |
| [138] | BATIK-AR | ASSEMBLR Studio | Android | Mobile devices | Points and badges |
| [139] | n/a | n/a | n/a | Mobile devices | Game-like features |
| [140] | Microorganisms | Unity, Autodesk 3Ds Max, Vuforia and Firebase | Android | Mobile devices | Quiz questions, timer, and scores |
| Ref. | Application Name | Development Tools | Operating System | Device | Gamification Elements |
|------|------------------|-------------------|------------------|--------|----------------------|
| [141] | Voluminis | ARCore, Unity, Firebase and Blender | Android | Mobile devices | Points and leaderboards |
| [142] | AssociAR | Unity and Vuforia | Android | Mobile devices | Game-like features |
| [143] | n/a | OpenCV and Unity | Android | Mobile devices | Points and leaderboards |
| [146] | n/a | Aurasma | Android and iOS | Mobile devices | Virtual rewards |
| [144] | EmoFindAR | Unity, Photon Unity Networking and Placenote SDK | Android | Mobile devices | Competitive and collaborative game modes, points, and quiz questions |
| [145] | n/a | n/a | n/a | Mobile devices | Board game, game-like features, quiz questions, points, cards, slides, and learning sheets |
| [147] | n/a | n/a | n/a | Mobile devices | Digital stories |
| [148] | Get ahead in medical knowledge | RAVVAR app | iOS | Mobile devices | Cards, slides, and learning sheets |
| [149] | n/a | ARFoundation library and Unity | Android | Mobile devices | Points, levels, badges, and achievements |
| [150] | SoLAR Kid | n/a | Android | Mobile devices | Achievements and points |
| [151] | Explorez and VdeUVic | ARIS | iOS | Mobile devices | Levels and quests |
| [152] | n/a | n/a | n/a | Mobile devices | n/a |
| [153] | n/a | n/a | n/a | Mobile devices | Objectives, levels, points, timer, virtual rewards, collaboration, feedback, challenges, and progression |
| [154] | n/a | Unity and Vuforia | Android and iOS | Mobile devices | Mini games and game-like features |
| [155] | n/a | ARIS | iOS | Mobile devices | n/a |
| [156] | n/a | Unity and Vuforia | Android and iOS | Mobile devices | n/a |
| [157] | n/a | ARFoundation, Unity and ARCore | Android | Mobile devices | Game-like features |
| [158] | n/a | n/a | n/a | Mobile devices | Points and game-like features |
| [159] | vAnswer | Unity and Vuforia | Android | Mobile devices | Quiz questions and points |
| [160] | Amazon Biology | Unity and Android Studio | Android | Mobile devices | Quiz questions and puzzles |
| [161] | n/a | n/a | n/a | Mobile devices | Game-like features, quests and points |
| [162] | n/a | Unity, Vuforia and Autodesk Maya | Android | Mobile devices | Quiz questions, timer, badges, and points |
| [163] | Arsinoë | Android Studio and TensorFlow | Android | Mobile devices | Quiz questions and points |
| [164] | BN Anatomy | ARFoundation, ARCore, Unity and Manomotion | Android | Mobile devices | Quiz questions, scores, timer, virtual rewards, progression, feedback, and competition |
### Table 3. Cont.

| Ref.   | Application Name | Development Tools | Operating System | Device     | Gamification Elements                        |
|--------|------------------|-------------------|------------------|------------|---------------------------------------------|
| [165]  | CybAR            | Unity and Vuforia | Android          | Mobile devices | Quiz questions and points                  |
| [166]  | GARMA            | Unity and Alibaba Cloud Elastic Compute Service | Android | Mobile devices | Game-like features, scores, and leaderboards |
| [167]  | PlayVisit        | n/a               | n/a              | Mobile devices | Points and virtual leaderboards            |
| [168]  | MagiPlay         | Unity and ARKit   | iOS              | Mobile devices | Points and levels                          |
| [169]  | n/a              | n/a               | n/a              | n/a         | Game-like features, tasks, and role-play elements |
| [170]  | RoboTIC          | Unity             | Windows Holographic OS | Microsoft HoloLens | Game-like features, badges, and achievements |
| [171,172] | n/a             | n/a               | n/a              | n/a         | n/a                                         |
| [173]  | n/a              | HP Reveal         | Android and iOS  | Mobile devices | Game-like features                          |
| [174]  | PlanetarySystemGO | Unity and Vuforia | Android          | Mobile devices | Game-like features, quiz questions, and points |
| [175]  | ARQuest          | Unity and Vuforia | Android          | Mobile devices | Virtual tokens, digital stories, and challenges |
| [176]  | n/a              | n/a               | n/a              | Mobile devices | Virtual rewards and points                  |
| [177]  | n/a              | n/a               | n/a              | Mobile devices | Game-like features, quiz questions, and scores |
| [178]  | TARGaLM          | n/a               | n/a              | Mobile devices | Points, badges, and leaderboards            |
| [179]  | MRPT             | Unity             | Android          | HTC Vive Pro HMD | Game-like features, scores, and feedback |
| [180]  | n/a              | n/a               | n/a              | Mobile devices | Game-like features                          |
| [181]  | STEAM-GAAR       | n/a               | n/a              | Mobile devices | Points, leaderboards, and virtual rewards   |
| [182]  | GARSTEM          | n/a               | n/a              | n/a         | n/a                                         |
| [183]  | n/a              | n/a               | n/a              | Mobile devices | Game-like features, feedback, points, and virtual rewards |
| [184]  | n/a              | n/a               | n/a              | Mobile devices | Scores and mini games                       |
| [185]  | n/a              | n/a               | n/a              | Leap Motion Controller | Levels, tasks, and virtual rewards |
| [186]  | n/a              | OpenCV            | n/a              | Mobile devices | Game-like features                          |
| [187]  | SolarSystemGO    | n/a               | n/a              | Mobile devices | Game-like features, quiz questions, points, and virtual rewards |
| [188]  | Hunting Game Generator | n/a | n/a          | Mobile devices | Game-like features and quiz questions     |
| [189]  | Xplorerafe+      | n/a               | n/a              | Mobile devices | Game-like features and quests              |
| [190]  | MySpira          | Unity, Vuforia, ARKit and ARCore | Android          | Mobile devices | Game-like features, quiz questions, and points |
| [191]  | Dragon Tale      | n/a               | n/a              | Mobile devices | Game-like features, mini games, quiz questions, points, and puzzles |
| [192]  | n/a              | n/a               | n/a              | Mobile devices | Quiz questions and points                  |
Table 3. Cont.

| Ref. | Application Name | Development Tools | Operating System | Device | Gamification Elements |
|------|------------------|-------------------|------------------|--------|-----------------------|
| [193] | n/a | Unity and Vuforia | Android | Mobile devices | Quiz questions and board games |
| [194] | n/a | OpenCV | n/a | Mobile devices | Game-like features |
| [195] | n/a | n/a | n/a | Mobile devices | Quests, puzzles, and levels |
| [196] | EduPARK | Unity and Vuforia | Android | Mobile devices | Quiz questions, points, and tasks |
| [197] | n/a | n/a | n/a | Mobile devices and SmartBands | Game-like features and tasks |
| [198] | AAR Book Model | n/a | n/a | n/a | n/a |
| [199] | Galaxy Shop | Unity | n/a | Touchizer [228] | Game-like features, quiz questions, scores, feedback, and levels |
| [200] | GaMbAR | Node.js, MySQL and HTML5 | n/a | Mobile devices and web-based environment | Game-like features, mini games, and levels |
| [201] | n/a | n/a | n/a | n/a | n/a |
| [202] | EduPARK | Unity and Vuforia | Android | Mobile devices | Quiz questions, points, and tasks |
| [203] | Guardians of the Mo’ o | ARIS | iOS | Mobile devices | Game-like features, levels and tasks |
| [204] | GreenDesigners | n/a | n/a | Mobile devices | Progression, challenges, virtual rewards, badges, role-play elements, collective intelligence responses, and scene settings |
| [205] | n/a | n/a | n/a | Mobile devices | Quiz questions and levels |
| [206] | n/a | n/a | n/a | n/a | n/a |
| [207] | n/a | Unity and Vuforia | Android | Mobile devices | Game-like features and objectives |
| [208] | Ingress (Niantic) | n/a | Android and iOS | Mobile devices | Game-like features, badges, points, and tasks |

Table 4. Empirical studies: Main findings.

| Ref. | Main Findings |
|------|---------------|
| [81] | Students found their augmented reality learning experience engaging, relevant, useful, and fun and regarded the quest completion and collaborative activities as highly motivating. |
| [137] | The overall experience was viewed as useful, motivating, and satisfactory by students. A friendly competition was created between students and teachers to see who would obtain the highest score. |
| [138] | By promoting exploratory behaviors, the augmented reality application provided students with learning benefits, who in turn developed positive attitudes and found the application absorbing and enjoyable. |
| [139] | Increased learning outcomes were observed for students who used the augmented reality game. |
| [140] | Students found the learning experience engaging and satisfactory; thus, the augmented reality application was characterized as a helpful learning tool. |
| [141] | Students’ learning motivation increased and the teaching process was more enjoyable. |
Table 4. Cont.

| Ref. | Main Findings |
|------|---------------|
| [142]| Although the application might not have the same outcomes in all contexts, positive learning results were observed in students with ASD. |
| [143]| Based on the survey responses, the augmented reality application promoted self-learning, deepened students’ knowledge, and increased their desire to learn. |
| [144]| The experience was intrinsically satisfactory with students showcasing positive emotions, which improved their mood and increased their involvement. Students who participated in the collaborative game demonstrated greater emotional affection, interest, and social interactions. |
| [145]| Significant differences were found between the control and experimental groups. Students who used the augmented reality application were deeply immersed in the experience and, hence, showcased improved learning outcomes, decreased negative emotions, and better flow state. |
| [146]| Students showcased a positive attitude toward using augmented reality in learning contexts as it positively impacted their engagement and motivation. Although the novelty of the activity attracts students, the challenge of designing and implementing augmented reality in the educational process effectively still remains. |
| [147]| The results indicated that the augmented reality application supported students’ language learning in the affective, social, and cognitive domains, and contributed to their learning outcomes. The application was regarded as satisfactory, motivational, and enjoyable. |
| [148]| Students found the learning experience motivating and demonstrated a high acceptance level. |
| [149]| By incorporating audiovisual elements in real time, the augmented reality application helped students gain new experiences, acquire new knowledge, and hone their skills. |
| [150]| Students who used the augmented reality application showcased improved scores during post-tests while simultaneously the number of low performers decreased. |
| [151]| Students spent most of their time carrying out learning tasks and demonstrated higher interactivity and engagement in co-regulation activities. Opportunities to promote and increase collaborative learning were also showcased. |
| [152]| Students found the application motivating and easy to use, appreciated the fact that they could learn at their own pace, and developed a positive attitude toward language learning. Using multimodal material, students acquired new vocabulary in a playful manner while their vocabulary retention rate also improved. |
| [153]| Students found the overall activity entertaining and were motivated to play the augmented reality game. After using the application, students showcased improved learning outcomes and increased retention rate. |
| [154]| Students assessed the application as an enjoyable, intriguing, and attractive way to improve their skills at Mathematics. |
| [155]| Students actively participated in the learning process and found the immersion element beneficial to their learning. |
| [156]| Students found the experience satisfactory and engaging, viewed the application positively, and regarded it as an invaluable learning tool in flipped classroom contexts. A positive correlation between students’ perceptions of the augmented reality application and their learning attitude was found. |
| [157]| Students who used the augmented reality game were more creative and focused during the learning process. Their active participation and enthusiasm increased when they noticed the existence of rewards. |
| [158]| Students found the experience enjoyable and interesting and were able to comprehend the concept of intelligent environments and how to program their behavior. |
| [159]| The majority of students found the application useful as it helped them comprehend the subject taught better. They also positively valued the motivating aspects, which urged them to repeat tasks and revise the material studied. |
| [160]| Augmented reality applications can be combined with image recognition to expand their utilities, functionalities, and use cases, and to enrich the learning and teaching processes via visual objects. |
| [161]| The gamified augmented reality application improved students’ motivation and created a relaxed learning atmosphere, which fostered collaborative learning and strengthened their willingness to discuss. |
| [162]| Although major differences in terms of motivation were not observed between the gamified and non-gamified applications, students who used the gamified version demonstrated higher knowledge gain. Points were the determining gamification element that urged students to participate when compared to virtual badges and timers. |
| [163]| By providing students with interactive images and information that can easily be repeated, promising learning outcomes can be yielded. |
Table 4. Cont.

| Ref.       | Main Findings                                                                                                                                                                                                                                                                                                                                                       |
|------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [164]      | Students showcased satisfactory results and enthusiasm and highlighted that the experience stood out from conventional teaching methodologies. The system was flexible, intuitive, presented clear commands, and had acceptable latency.                                                                                                                                         |
| [165]      | The application was regarded as useful to the students who acquired a better comprehension of cybersecurity and learned how to stay safe online.                                                                                                                                                                                                                           |
| [166]      | The application performance was good and the participants showed good acceptance levels, found it useful and interesting, and quoted that it could be used as an effective supporting tool in the implementation of various teaching aims.                                                                                                                                          |
| [167]      | Students demonstrated increased learning motivation and positive attitudes toward the application.                                                                                                                                                                                                                                                                  |
| [168]      | Students enjoyed the overall experience while being more engaged and presenting positive emotions.                                                                                                                                                                                                                                                                    |
| [169]      | The results indicated higher student motivation, participation, and learning outcomes.                                                                                                                                                                                                                                                                             |
| [170]      | The application increased students’ motivation and interest in programming.                                                                                                                                                                                                                                                                                             |
| [171, 172] | Most university professors are acquainted with the use of augmented reality and can perform the most trivial tasks with ease. Additionally, they believe that mobile learning using augmented reality can be incorporated into education and increase students’ engagement. Small differences between genders and continents were found.                                                                                     |
| [173]      | Students’ task completion improved and teachers regarded the augmented reality game as helpful and useful.                                                                                                                                                                                                                                                      |
| [174]      | The majority of students enjoyed the augmented reality game experience and would be more than willing to participate in similar activities. Teachers confirmed that the application fulfilled the contents and aims of the syllabus.                                                                                                               |
| [175]      | Students were really engaged and motivated during the learning activities. The size of the mobile device affected their collaboration.                                                                                                                                                                                                                                  |
| [176]      | Students who used the augmented reality application performed better, were more focused, and demonstrated more positive attitudes. Technology-enhanced contextualized learning can promote and increase students’ learning attitudes and performance.                                                                                                                     |
| [177]      | Students felt a sense of satisfaction, regarded the experience as suitable for their learning needs, and achieved better learning outcomes.                                                                                                                                                                                                                           |
| [178]      | Students found the overall approach more engaging, motivating, and interesting in comparison to traditional approaches and exhibited better learning outcomes.                                                                                                                                                                                                 |
| [179]      | Students felt more motivated while using the application particularly due to the positive reinforcement text and regarded it as fun, interesting, and intuitive.                                                                                                                                                                                                       |
| [180]      | The participants viewed the application positively as it promoted their environmental awareness and improved their language learning experience.                                                                                                                                                                                                                     |
| [181]      | The results indicated the correlation between grit and learning achievement as well as the application positive impact on improving students’ internal factors of grit—that is hope, purpose, practice, and interest.                                                                                                                                                  |
| [182]      | Students’ attitude toward the application, their intention of using it, as well as its practicability and entertainment aspects were the best predictors for its effective design.                                                                                                                                                                                      |
| [183]      | The results indicated that the augmented reality game positively affected students’ learning interests and motivations.                                                                                                                                                                                                                                                    |
| [184]      | The application helped students increase their spatial reasoning skills, helped narrow the gender gap in spatial reasoning, and was mostly helpful for students with lower prior spatial reasoning performance.                                                                                                                                                                          |
| [185]      | Students showcased great empathy with the augmented reality tool and demonstrated increased learning outcomes and better performance in comparison to traditional approaches.                                                                                                                                                                                   |
| [186]      | Students displayed improved writing skills and learning outcomes.                                                                                                                                                                                                                                                                                                   |
| [187]      | The augmented reality approach managed to effectively engage students, draw their attention, and promote interdisciplinary subject matter learning.                                                                                                                                                                                                                |
| [188]      | Students were motivated by the augmented reality tool and regarded it as a supportive tool to traditional teaching that trigger their interest and enjoyment.                                                                                                                                                                                                        |
| [189]      | The augmented reality application intrigued students’ motivation and excitement and increased their collaborative learning by instilling teamwork and discussions.                                                                                                                                                                                                 |
Table 4. Cont.

| Ref. | Main Findings |
|------|---------------|
| [190] | Students who used the augmented reality application were more engaged in the learning activity and answered questions more accurately. |
| [191] | The augmented reality application improved students’ learning outcomes while creating a fun and entertaining environment and integrating mini games. |
| [192] | The application supported technology-enhanced active learning and provided students with interactive visualizations in a more exciting and gratifying way. Students were more actively and passionately involved in their activities and preferred this teaching method over traditional ones as it was more efficient and intriguing. |
| [193] | Students exhibited improved knowledge retention and learning results. Better outcomes were observed for students who played the augmented reality game more times. |
| [194] | Students who used the augmented reality tool had better learning results and honed their writing skills. |
| [195] | The use of gamification and augmented reality supports binary lessons and increases students’ cognitive ability. |
| [196] | The application promoted active learning in an enjoyable manner and it was assessed as interactive and easy to use. |
| [197] | The application offered students more personalized learning opportunities, freedom, and choices in their learning, and increased their active involvement, satisfaction, positive attitude toward learning, exercise completion rate, and grades. |
| [198] | The specialists regarded the application as a suitable solution to engage and motivate students and increase their teamwork and communication skills. |
| [199] | The results indicated that using augmented reality games instead of computer games engages students more effectively. |
| [200] | The gamified augmented reality application improved students’ motivation and satisfaction. |
| [201] | Gamified augmented reality applications meet the essential requirements to be adopted in the educational process to better engage and motivate students. |
| [202] | Students perceived the application positively while regarding it as easy to use and enjoyable. Although negative perceptions were also found, the benefits of positive game characteristics outnumbered them. |
| [203] | Gamified augmented reality affects the educational process positively as it creates new immersive learning environments. Students’ feedback regarding their overall learning experience was positive. |
| [204] | When used in conjunction with gamification, augmented reality creates new learning opportunities as it constitutes an impactful learning approach for real-world and classroom settings and it enables a preparatory transition from informal learning activities to formal design-focused ones. |
| [205] | Based on teachers’ viewpoints, personalized gamified augmented reality experiences enable students to form a deeper learning of the given subject while increasing their engagement and to improve their learning outcomes through real-time feedback. |
| [206] | Gamified augmented reality experiences were positively viewed by students as they provide them with a sense of independence in their learning, they create more enjoyable learning environments, and can be applied to numerous courses. |
| [207] | There are learning differences between static and dynamic augmented reality learning experiences. Although students are motivated in both cases, they perform better and achieve greater learning outcomes in dynamic augmented reality environments. |
| [208] | Using gamified augmented reality has the potential to yield several educational benefits due to its motivational nature. |

The complete results of the countries in which the studies took place are displayed in Figure 2, as a total and based on their categories. The countries (RQ3) that mostly carried out empirical study research into the use of augmented reality and gamification are: Portugal, China, Malaysia, Spain, Taiwan, and Greece. The countries that carried out proposal and suggestion papers are: Greece, the United States, Hungary, Italy, and Mexico. The countries that mostly contributed with reviews, conceptual and theoretical papers are: Spain, the United States, and Portugal. Finally, based on the total amount of articles published, the countries that examined the use of augmented reality and gamification in education more actively were: Spain, Greece, Portugal, the United States, China, Malaysia, and Taiwan.
A mixed-method research approach was adopted as both qualitative analysis and descriptive quantitative analysis were used to analyze the data [136]. The results acquired from the analysis of the articles and their variables from all three categories are presented below. Particularly, the results are categorized as those concerning the empirical studies (general information, research methods, variables and tools, application development information, and gamification elements, as well as main findings) in Tables 1–4, the proposal and prototype papers (general information, country, and aims) in Table 5 and the review, conceptual and theoretical papers (general information, aims, and main findings) in Table 6.

The complete results of the countries in which the studies took place are displayed in Figure 2, as a total and based on their categories. The countries (RQ3) that mostly carried out empirical study research into the use of augmented reality and gamification are: Portugal, China, Malaysia, Spain, Taiwan, and Greece. The countries that carried out proposal and suggestion papers are: Greece, the United States, Hungary, Italy, and Mexico. The countries that mostly contributed with reviews, conceptual and theoretical papers are: Spain, the United States, and Portugal. Finally, based on the total amount of articles published, the countries that examined the use of augmented reality and gamification in education more actively were: Spain, Greece, Portugal, the United States, China, Malaysia, and Taiwan.

Due to the number of variables and studies, the information is clustered and displayed accordingly on different tables to improve readability. Specifically, Table 1 depicts the main information of the empirical studies, Table 2 showcases their research methods, variables, and tools, Table 3 presents their application development information and gamification elements, while Table 4 quotes their main findings (RQ4).

Based on the above-presented information, several observations can be made. Figure 3 depicts the results regarding the educational stage, which the articles emphasized. Most of the studies focused on higher education (freq. = 31, pct. = 42.47%), followed by primary education (freq. = 20, pct. = 27.4%), secondary education (freq. = 11, pct. = 15.07%), and K-12 education (freq. = 7, pct. = 9.59%) (RQ5). In total, 4 (5.48%) studies did not specify the educational stage or age of the participants. As it can be seen in Figure 4, the majority of studies focused on students’ cognitive development (freq. = 63, pct. = 86.30%), 2 (2.74%) studies focused on students’ social–emotional development, 3 (4.11%) studies emphasize both students’ cognitive and social–emotional development, while 5 (6.85%) studies did not give any specification (RQ6). Although some studies analyze and take teachers’ viewpoints into account, the majority of the studies use students as the main participants (RQ7). Despite the fact that the goals of the studies are diverse, most of them aim at improving students’ learning experience and academic performance while increasing their motivation and engagement and providing them with an intriguing and enjoyable learning environment (RQ8). When clustering the main areas of focus of the given studies, the majority of them focused on STEAM-related fields, particularly computer science and mathematics, followed by language learning, medical and healthcare education, culture and history, as well as literacy skills (RQ9).
Using gamified augmented reality has the potential to yield several educational benefits due to its motivational dynamic augmented reality environments. Although students are motivated in both cases, they perform better and achieve greater learning outcomes in applications to numerous courses. Gamified augmented reality experiences were positively viewed by students as they provide them with a sense of independence in their learning, they create more enjoyable learning environments, and can be applied to numerous courses.

There are learning differences between static and dynamic augmented reality learning experiences. Although most of the questionnaires and surveys used were ad hoc, popular, and validated in the field of education questionnaires, such as the Technology Acceptance Model (TAM) [209,215], Instructional Material Motivation Survey (IMMS) [214], Presence Questionnaire [216], Motivated Strategies for Learning Questionnaire (MSLQ) [227], Intrinsic Motivation Inventory (IMI) [225], Achievement Emotions Questionnaire (AEQ) [211], System Usability Scale (SUS) [222], Goal–Question–Metric (GQM) [229], and the Flow Experience Questionnaire [212] were also used. Some studies followed guidelines and adopted items in their survey from questionnaires, such as those presented in [210,215,218,220,221,223,224,226,230,231] (RQ10). The main variables used were related to students’ motivation, viewpoints, and learning outcomes (RQ10).

Moreover, the research methods that the studies of this category used are displayed in Figure 5. The majority of the studies used quantitative approaches (freq. = 45, pct. = 61.64%) followed by qualitative (freq. = 14, pct. = 19.18%) and mixed (freq. = 14, pct. = 19.18%) methods (RQ10). Although most of the questionnaires and surveys used were ad hoc, popular, and validated in the field of education questionnaires, such as the Technology Acceptance Model (TAM) [209,215], Instructional Material Motivation Survey (IMMS) [214], Presence Questionnaire [216], Motivated Strategies for Learning Questionnaire (MSLQ) [227], Intrinsic Motivation Inventory (IMI) [225], Achievement Emotions Questionnaire (AEQ) [211], System Usability Scale (SUS) [222], Goal–Question–Metric (GQM) [229], and the Flow Experience Questionnaire [212] were also used. Some studies followed guidelines and adopted items in their survey from questionnaires, such as those presented in [210,215,218,220,221,223,224,226,230,231] (RQ10). The main variables used were related to students’ motivation, viewpoints, and learning outcomes (RQ10).
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Furthermore, a lack of a thorough display of examples of the developed applications, a detailed description of the methods, tools, and particularly of the approaches used for their development, technical, as well as provision of resources and repositories for readers to use and test the applications themselves was evident. Some examples of development methodologies, models, and approaches used during the Software Development Life Cycle (SDLC) were: Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model [81,232], incremental development [138], waterfall model [138,139], agile methodology [140], quasi-experimental design [141], and the octalysis framework [142] (RQ11). Future studies should provide such information so that it would be possible to answer key research questions, such as how specific development methodologies and approaches affect the success of adopting and using technologies and applications in education. Although most of the studies (freq. = 36, pct. = 49.32%) did not specify the particular operating system on which their application was running, from the ones that did, android (freq. = 24, pct. = 32.88%) was the preferred operating system, followed by iOS (freq. = 6, pct. = 8.22%), both android and iOS (freq. = 5, pct. = 6.85%) and Windows Holographic OS (freq. = 2, pct. = 2.74%), as it can also be seen in Figure 6 (RQ11). This fact can be justified when taking into consideration the operating systems’ worldwide market share [233] and the fact that the most popular augmented reality Software Development Kits (SDKs) natively support the development of applications for the Android operating system. The Unity platform (freq. = 26, pct. = 35.62%) was the most widely used development tool along with Vuforia engine and SDK (freq. = 15, pct. = 20.55%) (RQ11). It is worth noting that the majority of the studies (freq. = 34, pct. = 46.85%) did not specify which development tools were used for the creation of their application. Regarding the devices used during the experiments (Figure 7), mobile devices had the overwhelming majority as they were used in a total of 61 studies (83.56%) with only a few studies utilizing specialized equipment, such as Microsoft HoloLens (freq. = 2, pct. = 2.74%), HTC Vive Pro HMD (freq. = 1, pct. = 1.37%), Leap Motion Controller (freq. = 1, pct. = 1.37%), and Touchizer [228] (freq. = 1, pct. = 1.37%), while 7 (9.59%) studies did not specify the particular devices that were used (RQ12). As far as the gamification elements used are concerned, the applications mostly used points, scores, leaderboards, game-like features, mini games and puzzles, virtual rewards (e.g., badges, achievements, tokens, etc.), objectives, quests and tasks, quiz questions, challenges and difficulty levels, instant feedback, timer, and digital storytelling (RQ13). Moreover, studies capitalized on students’ competitive spirit and collaborative learning activities. Role-play and digital storytelling were also the main aspects of certain applications while other studies used additional external material in the form of cards, board games, slides, learning sheets, etc.
To suggest how an augmented reality escape room could support and enrich a wide range of learning experiences.

To show how an augmented reality application can support and guide students during their orientation week.

To propose an interdisciplinary approach using augmented reality and gamification elements to support students’ mathematics learning.

To present a framework for creating mixed reality gamification applications to allow students to train in immersive 3D environments.

To showcase the potential of using gamified augmented reality experiences through mobile applications in educational context.

To design and create an augmented reality game that promotes primary school students’ programming skills development.

To enhance the educational process of teaching and learning mathematics through the combinational use of gamification and augmented reality.

To showcase how gamified elements and augmented reality can provide immersive practicing exercises.

To present a gamification concept for augmented reality virtual laboratories to increase students’ practical skills.

To examine how augmented reality and tangible user interfaces can assist in learning computer science concepts and programming skills, such as debugging.

To showcase how gamified elements and augmented reality can provide immersive practicing exercises.

To showcase how the use of blockchain and augmented reality can assist in keeping track of digital assets in virtual spaces.

To explore how augmented reality tools that utilize gamification elements can increase students’ spatial skills.

To explore how agile methodologies and gamification elements can positively affect the success of adopting and using technologies and applications in educational context.

To present how the adoption of an extended reality platform that uses gamification can support conventional educational practices in laboratory-based training.

To showcase how gamified elements and augmented reality can provide immersive practicing exercises.

To explore how augmented reality and tangible user interfaces can assist in learning computer science concepts and programming skills, such as debugging.

To enhance the educational process of teaching and learning mathematics through the combinational use of gamification and augmented reality.

To showcase how gamified elements and augmented reality can provide immersive practicing exercises.

To propose an interdisciplinary approach using augmented reality and gamification elements to support students’ mathematics learning.

To present a framework for creating mixed reality gamification applications to allow students to train in immersive 3D environments.

To showcase how an augmented reality application can support and guide students during their orientation week.

To suggest how an augmented reality escape room could support and enrich a wide range of learning experiences.

Table 5. Proposal and prototype papers: general information.

| Ref. | Country          | Aims                                                                 |
|------|------------------|----------------------------------------------------------------------|
| [232] | Malaysia         | To explore how using gamification and augmented reality can engage students in language learning. |
| [234] | Australia        | To examine how augmented reality and tangible user interfaces can assist in learning computer science concepts and programming skills, such as debugging. |
| [235] | Hungary          | To showcase how gamified elements and augmented reality can provide immersive practicing exercises. |
| [236] | Spain            | To enhance the educational process of teaching and learning mathematics through the combinational use of gamification and augmented reality. |
| [237] | United States    | To showcase how the use of blockchain and augmented reality can assist in keeping track of digital assets in virtual spaces. |
| [238] | Germany          | To present a gamification concept for augmented reality virtual laboratories to increase students’ practical skills. |
| [239] | Hungary          | To explore how augmented reality tools that utilize gamification elements can increase students’ spatial skills. |
| [240] | Greece           | To showcase how an extended reality platform that uses gamification can support conventional educational practices in laboratory-based training. |
| [241] | Italy            | To present an augmented reality application enriched with game design elements to facilitate university students’ learning about human anatomy. |
| [242] | India            | To design and create an augmented reality game that promotes primary school students’ programming skills development. |
| [243] | Spain            | To showcase the potential of using gamified augmented reality experiences through mobile applications in educational context. |
| [244] | United States    | To propose an interdisciplinary approach using augmented reality and gamification elements to support students’ mathematics learning. |
| [245] | The Netherlands  | To present a framework for creating mixed reality gamification applications to allow students to train in immersive 3D environments. |
| [246] | Finland          | To show how an augmented reality application can support and guide students during their orientation week. |
| [247] | United States    | To suggest how an augmented reality escape room could support and enrich a wide range of learning experiences. |
Table 5. Cont.

| Ref. | Country  | Aims                                                                                                                                 |
|------|----------|---------------------------------------------------------------------------------------------------------------------------------------|
| [248] | Greece   | To present the developmental process of creating an augmented reality application that uses gamification aspects to support learning and teaching activities. |
| [249] | Argentina | To present a gamified augmented reality application that aims at supporting collaborative learning, enriching students’ learning experiences, and increasing teacher–student interaction. |
| [250] | Thailand | To propose a gamified augmented reality application to enhance students’ grit.                                                          |
| [251] | Mexico   | To explore how augmented reality applications that use gamification elements can support and increase students’ reading abilities as a means to further strengthen their personal, work, and social relations. |
| [252] | Greece   | To evaluate whether mixed reality digital games can support and enhance future learning and teaching of various educational contexts.           |
| [253] | Italy    | To show a prototype gamified augmented reality application that aims to improve cultural heritage learning.                                |
| [254] | Romania  | To showcase the results of applying a gamified augmented reality application to facilitate foreign language learning while making it more enjoyable. |
| [255] | Brazil   | To propose an augmented reality framework that uses gamification elements to facilitate and support the learning process of students with intellectual disabilities. |
| [256] | Taiwan   | To present the benefits of using content-aware augmented reality applications in educational settings.                                    |
| [257] | Greece   | To explore how gamified augmented reality experiences can support lifelong learning and cultural education based on an augmented reality application, which focuses on the subject of science. |
| [258] | Greece   | To explore how augmented reality and gamification can facilitate and support the comprehension of subject-specific matters while engaging learners in an enjoyable experience. |
| [259] | Mexico   | To present the development of an augmented reality mobile application that uses gamification elements to improve students’ geography knowledge. |

Figure 7. Empirical studies: devices used.
### Table 6. Review, conceptual, and theoretical papers: general information.

| Ref. | Country      | Aims                                                                 | Main Findings                                                                                                                                                                                                 |
|------|--------------|----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [260] | United States| To discuss the history of instructional design and technology field in four time periods while presenting technologies such as augmented reality, gamification, mobile learning, etc. | In order for new technologies to be adopted in education, teachers should realize their value, experience positive effects themselves, and feel confident and comfortable when using them. Learning and instructional design theories have evolved to technology-centered to address the new requirements. |
| [261] | Philippines  | To propose a supplementary learning tool framework for developing educational applications using augmented reality, Unity, and Vuforia to enhance the learning process. | Augmented reality and gamification as supplementary learning tools are effective.                                                                                                                                 |
| [262] | Spain        | To present the key elements that must be taken into account when creating online tools that utilize gamification and augmented reality. | When combined with gamification, mixed reality applications can offer several benefits to students and the educational process.                                                                                   |
| [263] | Portugal     | To comprehend and analyze the gaming strategies that can be used in immersive technologies to improve foreign language learning. | Using gaming strategies along with immersive technologies, and particularly augmented reality can facilitate and enhance foreign language learning.                                                                  |
| [264] | Spain        | To present a research project that applies an instructional technology-based model in a bilingual education context using augmented reality and gamification. | The use of gamification and augmented reality resulted in several educational benefits, such as improved health awareness, engagement, and linguistic skills, and increased physical exercise. |
| [265] | Portugal     | To provide an overview of the concepts of immersive learning systems and gamification strategies. | n/a                                                                                                                                                                                                         |
| [266] | United Kingdom| To analyze the existing virtual and augmented reality taxonomies while focusing on their interconnection with gamification elements. | A proposed taxonomy and its facets were presented, which classify immersive technologies based on several attributes, including gamification.                                                                   |
| [267] | Australia    | To present the advances made in the educational sector via the Unity game engine and to showcase how it can contribute to teaching students to use immersive technologies. | Practices were suggested to better implement gamification and mixed reality applications in education during the COVID-19 pandemic.                                                                           |
| [268] | China        | To examine the factors of an augmented reality application design that can better support students’ early language acquisition. | The main augmented reality learning activities and design strategies were presented. Specifically, the use of game mechanisms with a discovery strategy improved students’ motivation. |
| [269] | United States| To showcase how gaming technology innovations in the form of digital games and augmented reality can impact education and particularly in the field of health and physical education. | n/a                                                                                                                                                                                                         |
| [270] | Spain        | To present and analyze some indicative applications and activities that use ICT, including games and augmented reality in teaching activities. | Augmented reality, gamification, and mobile learning have the potential to reshape educational practices and offer improved learning outcomes.                                                                     |
| [271] | India        | To examine how augmented reality, gamification, and adaptive learning can increase the engagement of Massive Open Online Courses (MOOCs). | When adopted by MOOCs, augmented reality, gamification, and adaptive learning can lead to more interactive, pervasive, and engaging learning environments in diverse educational domains. |
| [272] | United States| To present instructional design principles that can assist in the development of improved augmented reality learning experiences. | Fantasy, challenge, and curiosity are the main design principles that can leverage the unique affordances of augmented reality in education.                                                                     |
Furthermore, Table 5 depicts the basic information regarding the proposal and prototype studies, such as country and aims. The country, aims, and main findings of the review, conceptual, and theoretical papers are displayed in Table 6.

The majority of the proposal and prototype papers focused on higher education (freq. = 10, pct. = 37.04%), followed by primary education (freq. = 6, pct. = 22.22%), K-12 education (freq. = 5, pct. = 18.52%) and secondary education (freq. = 1, pct. = 3.7%) (Figure 8). In total, 5 (18.52%) studies did not specify the educational stage that they put emphasis on. The studies mostly focus on STEAM-related fields and language learning as it was also the case for the empirical studies (RQ14).

![Figure 8. Proposal and prototype papers: educational stages.](image)

**Summary of the Results and Main Findings**

To summarize the main findings and details of the above-mentioned information and studies, it can be said that the main findings of the empirical studies, proposal, and prototype papers as well as review, conceptual, and theoretical papers, all came to the same conclusion that several benefits could be yielded from the integration of augmented reality and gamification into the educational process (RQ15). To address RQ1, the main findings are summarized. Particularly, when used in a student-centered manner, following proper educational approaches and strategies and taking students’ knowledge, interests, unique characteristics, and personality traits into consideration, the use of augmented reality and gamification can bring about positive outcomes, benefits for students, assist educators, improve the educational process, and facilitate the transition toward technology-enhanced learning. More specifically, increased students’ engagement, motivation, active participation, knowledge acquisition, focus, curiosity, interest, enjoyment, and learning outcomes were observed. Positive behavioral and psychological changes as well as opportunities to create personalized learning experiences were also demonstrated. While being immersed in the learning activities, students could experience situations and environments that they would not have the chance to experience otherwise and found it easier to comprehend the learning material since they could acquire hands-on experience in safe virtual environments. Moreover, new opportunities to promote and adopt collaborative learning activities emerged. It is worth noting that despite the vast number of studies explored in this literature review report positive results, there are industry-focused reports and projects that failed to result in positive outcomes.

The use of gamification elements was also viewed as positive in the educational process. Specifically, it made the overall learning experience more enjoyable and intriguing, increased students’ engagement, and kept them more motivated not only to stay focused and participate actively but also to perform better, which in turn led to increased academic
performance. The use of virtual rewards was a significant factor, which, in several cases, further improved students’ learning motivation. Students also positively regarded the use of difficulty levels, instant feedback, and the ability to review their performance. Opportunities to create collaborative learning activities and to capitalize on the spirit of friendly competition were also observed.

In addition to students’ viewing the integration of augmented reality and gamification into education as positive, educators also valued it equally. The selection of the appropriate strategies and approaches was deemed as a determining factor to the successful integration. No matter how much augmented reality, gamification, and technology in general advance, educators are the ones who should familiarize themselves with the state-of-the-art technologies, applications, and approaches, and become more comfortable and confident when using them to incorporate them into their teaching process. The role of educators still remains crucial in the educational process and for students’ development, and they are the ones who should strive to offer their students the best learning experiences possible while taking advantage of novel technological tools. With the aim of facilitating the adoption of augmented reality and gamification in the educational process and selecting the most suitable approach, there is a clear need for validated evaluation tools and theories to be developed to assess the applied interventions and measure their effects in a standardized and valid manner [86].

Based on the above-presented results, Spain, Greece, Portugal, the United States, China, Malaysia, and Taiwan were the countries that examined most the integration of augmented reality and gamification into education. Most studies were published in the year 2020. Higher education was the educational stage, which the majority of the studies focused on while the STEAM-related subjects, which are connected with problems that students face daily [273], and language learning, were the subjects investigated most. Assessing the impact of augmented reality and gamification in education and comprehending the participants’ viewpoints were the main aims of most studies. Students were the main target sample with most of the variables analyzed being factors related to them. Ad hoc questionnaires and qualitative research approaches were mostly used. A satisfactory number of qualitative studies were also carried out, which is essential to offer more collective insights into designing better UX [274]. Although the documentation of the development process was not satisfactorily displayed and examples of the developed application were not presented in several cases, most of the studies focused on the use of mobile devices, used Unity and Vuforia as their main development platforms, and android as the operating system of their application. Not using specialized equipment to carry out the experiments showcases the potential of implementing augmented reality experiences easily and affordably in the educational process. Finally, the vast majority of the studies focused solely on students’ cognitive development. As one of the main roles of education is to promote students’ social–emotional development, more emphasis should also be placed on evaluating the impact of augmented reality and gamification on students’ social–emotional development, and how education could contribute toward improving it.

6. Discussion

Along with the technological advances, the teaching and learning methodologies and approaches are also evolving to address the new and upcoming educational needs and requirements [275]. Due to this fact, technology-enhanced learning has become more essential, learning activities are progressing toward being more student-centered, and the educational content is enriched by multimedia elements to be more interactive [276]. Nonetheless, it is of great significance to take cultural, moral, and ethical factors into account when trying to adopt and implement new technologies and approaches in educational context to achieve better outcomes and facilitate the dissemination of technology [31,277].

Both augmented reality and gamification are in line with the engagement theory, which supports technology-enhanced teaching and learning [278]. Additionally, they are in accordance with the instructional theory, which supports that when students cultivate their
skills in environments similar to real ones, successful learning can be attained [279,280]. Using augmented reality and gamification can enhance students’ 21st-century skills, which are fundamental to the educational process [15], and help them cultivate their decision-making, social interaction, conflict resolution, and emotional awareness, which are essential in modern society [281]. Hence, they play a vital role in enriching the teaching and learning activities and transforming traditional education into technology-enhanced education while increasing learning outcomes. Both gamification and augmented reality are regarded as essential in developing instructional media, theories, approaches, and designs, which can be applied in several domains, including education [260]. Additionally, they promote and support ubiquitous learning and pervasive learning. Particularly, augmented reality is regarded as a significant innovation in the field of educational technology [282] and as an emerging technology, which can facilitate the creation of inclusive learning experiences [283]. On the other hand, several aspects and elements of gamification are based on educational psychology; therefore, gamification plays a significant role in the development of educational technology and the construction and transformation of education [91,284].

Through the engaging and immersive experiences that are created in safe and hybrid environments, which support guided learning, several educational benefits can be yielded and learning opportunities are brought about [285,286], such as students acquiring knowledge based on hands-on experiences [234] and the potential to apply new pedagogical approaches and methodologies [287]. Hence, experiential learning, which supports concrete experiences, reflective observation, abstract conceptualizations, and active experimentation, and in which learners personally experience and control the learning activity, is promoted [288,289].

Due to the versatility of augmented reality and gamification, both individual and collaborative hybrid learning environments can be created [290]. In particular, by participating in authentic group activities, students demonstrate increased engagement, enthusiasm, and interest in the learning activities, participate more actively, and enhance their critical thinking and problem-solving skills [291–293]. As gamification promotes socialization [294], it can create enjoyable social interactions among groups while promoting satisfaction, productivity, collaboration, positive behaviors, and communication [295–297]. Thus, gamification elements acting as motivators can positively affect performance in general, even in fields that are not directly related to education, and assist in building core career competencies [298,299], while simultaneously serving as social comparison tools [111,143].

In order to create effective gamification strategies for learning through augmented reality and digital media, thorough planning and analysis, which take learners’ characteristics, learning objectives, as well as the multimedia educational content and activities into consideration must first be conducted [300]. Additionally, to achieve the desired for each case learning outcomes, it is critical to provide students with appropriate and instantaneous feedback [301], to assess their perceived enjoyment and usefulness [302], to set clear goals, instructions, and expectations [303,304], and to design and incorporate activities that stimulate students’ intrinsic and extrinsic motivations [305]. Based on the motivational theory, as students’ motivation increases, so do their engagement, involvement, and commitment [306]. In addition, high motivation is a significant predictor of deep immersion, which can positively affect students’ academic performance [307], time spent on learning activities [308], higher-order thinking, and meaningful learning [309], as well as behaviors and attitudes toward learning [212]. As games and gamification elements are intrinsically satisfying, they can also positively impact students’ emotions [144,310], which are essential aspects of education as they can either enhance or impede learning and students’ attention and engagement [145,311]. Consequently, augmented reality and gamification support the constructivist learning theory and situated learning theory, which in turn assert that when students actively participate in the learning activities, they are more inclined to learn and achieve better learning outcomes [17,146,312].

Gamified augmented reality applications can impact students’ social, cognitive, and emotional domains [147]. Therefore, many factors should be taken into account when designing
and developing such educational applications [313,314]. Due to the multimodal nature of both gamification and augmented reality, particular attention should be paid to designing learning activities that do not overload students’ cognitive capabilities [315,316]. Thus, the diverse gamification elements, which are used to provide a positive and interactive learning climate [93], and engage students more actively and for longer time periods [317], should focus on addressing specific educational contexts and activities [318].

7. Conclusions

The COVID-19 pandemic has made the need for technology-enhanced learning more evident. Students’ educational requirements and expectations have drastically changed as they grow up in environments where technology is an essential part of everyday life. Consequently, students are seeking for more meaningful learning experiences through educational means and approaches, which are more engaging, motivating, and immersive. The application of augmented reality and gamification in education is gaining ground.

The aim of this study was to scrutinize the existing literature concerning the use of gamification and augmented reality in the educational process. Therefore, a systematic literature review was carried out. According to the results, their use in teaching and learning activities can improve the overall educational process, while also assisting educators and yielding numerous merits for students. Additionally, their integration into education facilitates the transition toward technology-enhanced learning. Nonetheless, in order for all these to be realized, their integration should follow proper educational strategies and approaches, have students at its core, and take students’ knowledge, interests, unique characteristics, and personality traits into account.

In particular, the use of augmented reality applications enriched with gamification elements resulted in increasing students’ engagement, motivation, active participation, knowledge acquisition, focus, curiosity, interest, enjoyment, academic performance, and learning outcomes. Furthermore, positive behavioral, attitudinal, and psychological changes were demonstrated. The overall experience and impact of their combination was positively viewed and assessed by both students and educators. Gamification elements had a significant impact on teaching and learning activities. Virtual rewards, in particular, were a vital factor in improving learning motivation and students’ engagement. Their ability to create immersive environments, which promote collaborative and personalized learning experiences, was highly regarded. Finally, based on the analysis, the use of gamification elements and augmented reality technology contributed significantly to promoting and enhancing students’ cognitive and social–emotional development.

The merits acquired through combining gamification with augmented reality were of great significance. Nonetheless, in order for them to be more widely accepted and adopted in education, general innovation and improvement through educational technology should be encouraged, standardized validation and evaluation tools need to be developed, more effective learning strategies and approaches need to be further explored, and cross-cultural studies that take into consideration the participants’ unique characteristics should be carried out. Finally, it is of great importance not only to focus on improving students’ academic performance but also to explore and enhance their social–emotional development and 21st-century skills cultivation.

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