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Review

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

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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.

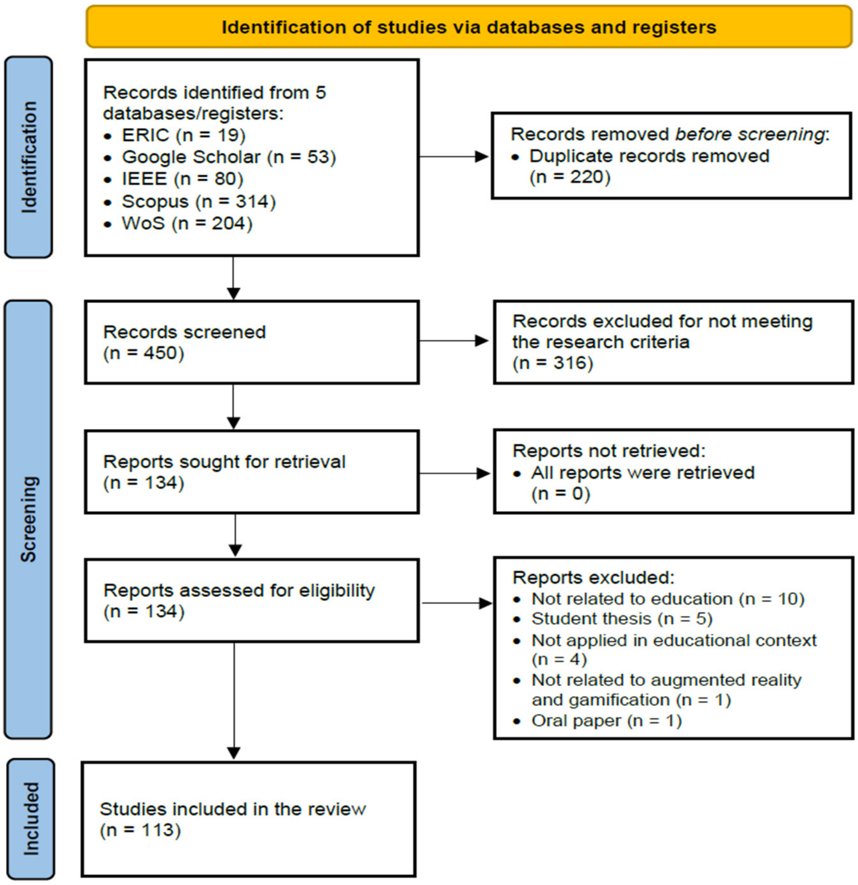

Figure 1. Prisma flow diagram.

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 (French)	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 and social–emotional	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 and social–emotional	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 (English)	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.

Table 1. *Cont.*

Ref.	Country	Educ. Stages	Focus Area	Develop. Category	Sample	Aims
[163]	Germany	K-12 education	Culture and language learning	n/a	n/a	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	6 participants (university students and/or professionals)	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	91 university students (41 Bachelor, 34 Master, 16 Ph.D.)	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, and 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.

Table 1. *Cont.*

Ref.	Country	Educ. Stages	Focus Area	Develop. Category	Sample	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.

Table 1. *Cont.*

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.

Table 1. *Cont.*

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]

Table 2. *Cont.*

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

Table 2. *Cont.*

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 survey
[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

Table 3. *Cont.*

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	Game-like features
[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 rewards
[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-playelements
[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	Univty, 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.

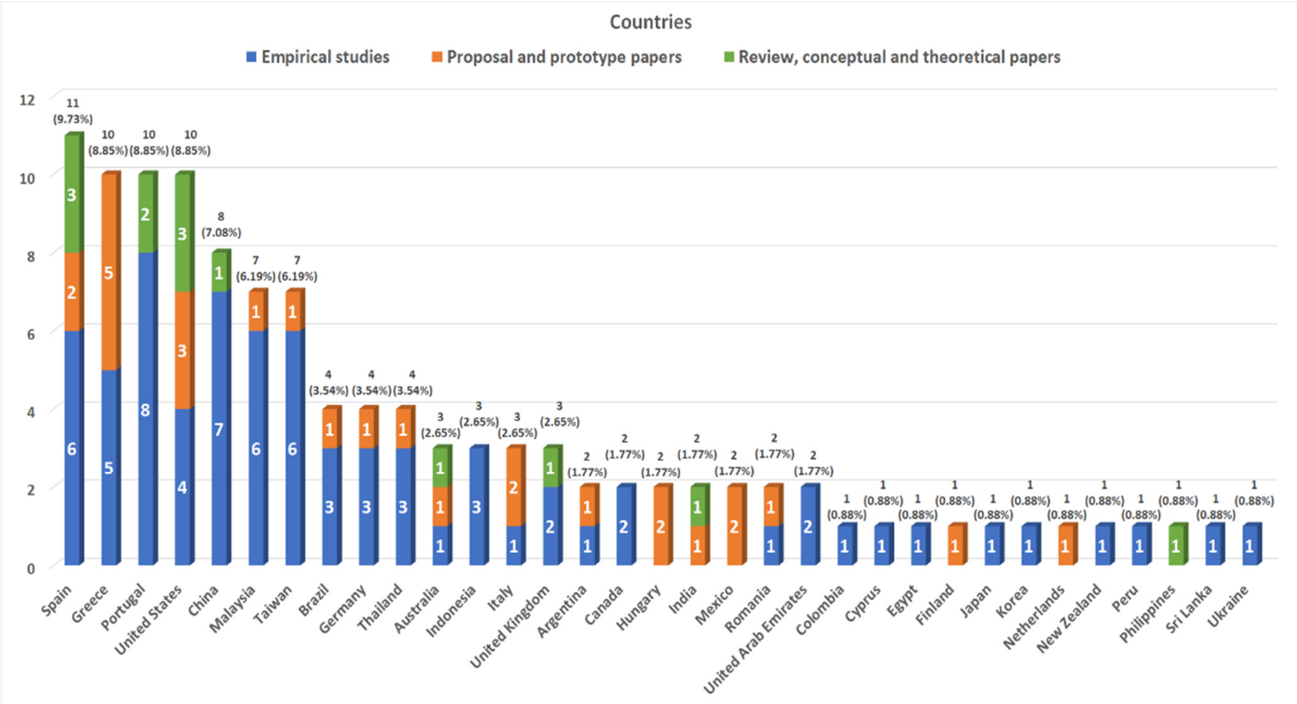

Figure 2. Countries in which the experiments/studies were carried out.

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).

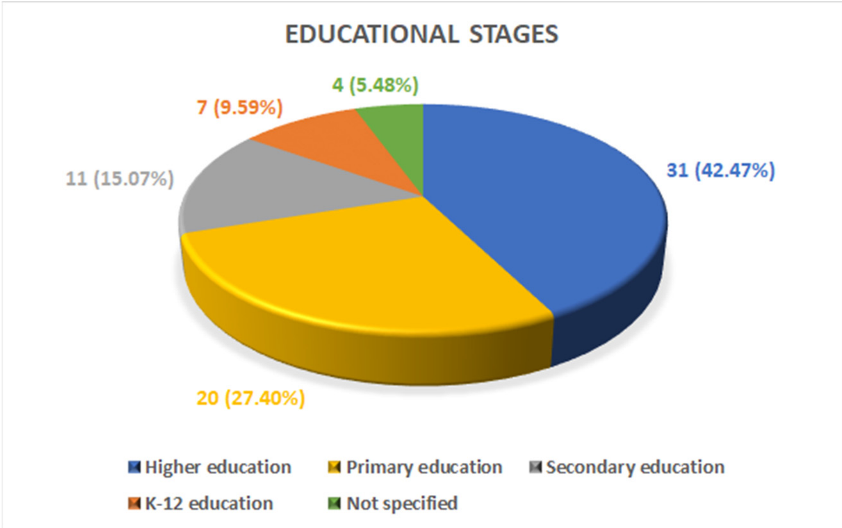

Figure 3. Empirical studies: educational stages.

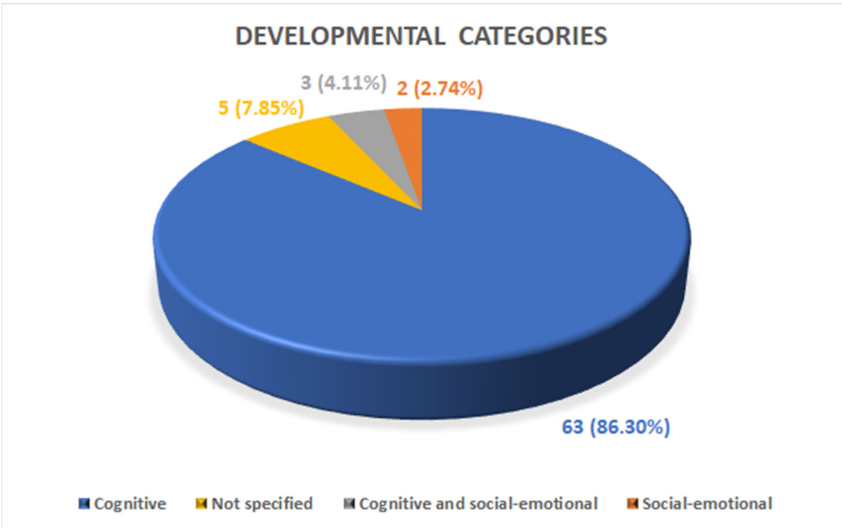

Figure 4. Empirical studies: developmental categories.

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).

Figure 5. Empirical studies: research methods.

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.

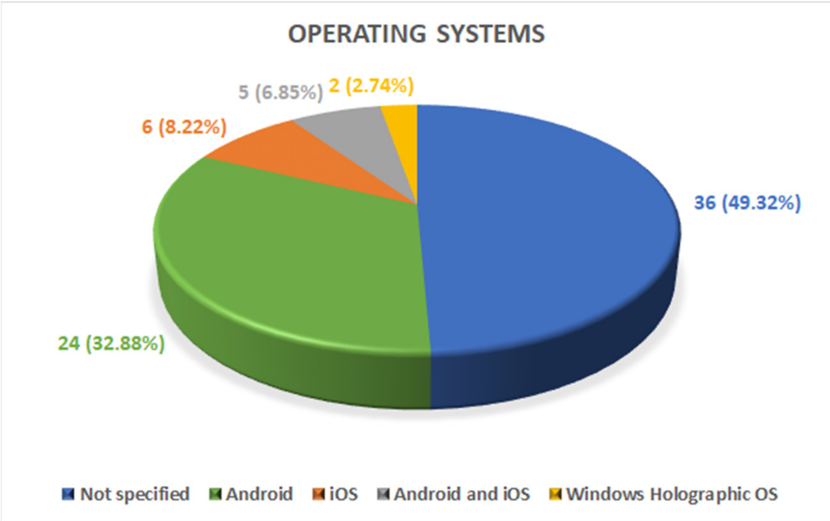

Figure 6. Empirical studies: operating systems.

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.

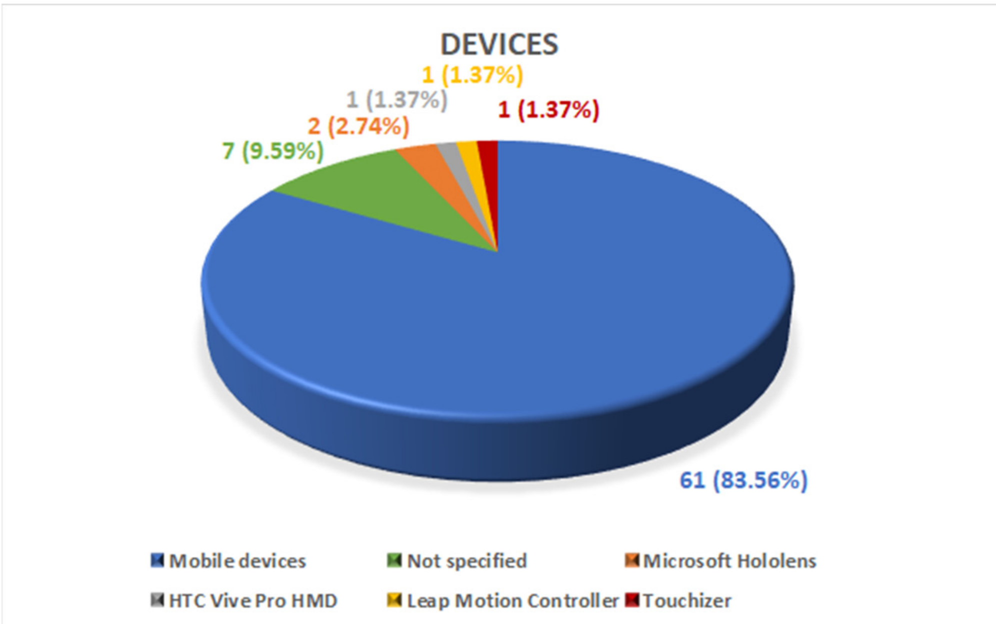

Figure 7. Empirical studies: devices used.

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).

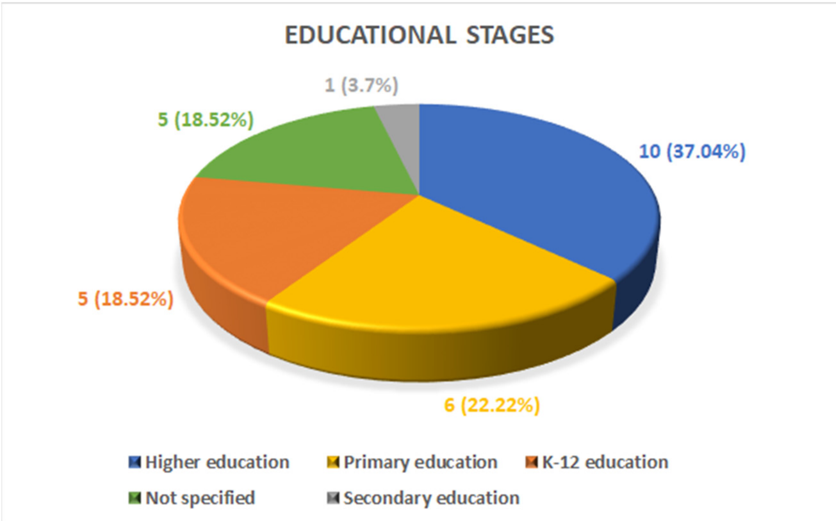

Figure 8. Proposal and prototype papers: educational stages.

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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References

1. Becker, S.A.; Cummins, M.; Davis, A.; Freeman, A.; Hall, C.G.; Ananthanarayanan, V. *NMC Horizon Report: 2017 Higher Education Edition*; The New Media Consortium: Austin, TX, USA, 2017.
2. Daniel, S.J. Education and the COVID-19 Pandemic. *PROSPECTS* **2020**, *49*, 91–96. [CrossRef]
3. Pokhrel, S.; Chhetri, R.A. Literature Review on Impact of COVID-19 Pandemic on Teaching and Learning. *High. Educ. Future* **2021**, *8*, 133–141. [CrossRef]
4. Prensky, M. Digital Natives, Digital Immigrants Part 2: Do They Really Think Differently? *Horizon* **2001**, *9*, 1–6. [CrossRef]
5. Chang, C.Y.; Lai, C.L.; Hwang, G.J. Trends and Research Issues of Mobile Learning Studies in Nursing Education: A Review of Academic Publications from 1971 to 2016. *Comput. Educ.* **2018**, *116*, 28–48. [CrossRef]
6. Admiraal, W.; Huizenga, J.; Akkerman, S.; Dam, G.T. The Concept of Flow in Collaborative Game-Based Learning. *Comput. Hum. Behav.* **2011**, *27*, 1185–1194. [CrossRef]
7. Anastasiadis, T.; Lampropoulos, G.; Siakas, K. Digital Game-Based Learning and Serious Games in Education. *Int. J. Adv. Sci. Res. Eng.* **2018**, *4*, 139–144. [CrossRef]
8. Crisol-Moya, E.; Romero-López, M.A.; Caurcel-Cara, M.J. Active Methodologies in Higher Education: Perception and Opinion as Evaluated by Professors and Their Students in the Teaching-Learning Process. *Front. Psychol.* **2020**, *11*, 1703. [CrossRef]
9. Zeidler, D.L.; Sadler, T.D.; Simmons, M.L.; Howes, E.V. Beyond STS: A Research-Based Framework for Socioscientific Issues Education. *Sci. Educ.* **2005**, *89*, 357–377. [CrossRef]
10. Barab, S.; Dede, C. Games and Immersive Participatory Simulations for Science Education: An Emerging Type of Curricula. *J. Sci. Educ. Technol.* **2007**, *16*, 1–3. [CrossRef]
11. Billingsley, G.; Smith, S.; Smith, S.; Meritt, J. A Systematic Literature Review of Using Immersive Virtual Reality Technology in Teacher Education. *J. Interact. Learn. Res.* **2019**, *30*, 65–90.
12. Zawacki-Richter, O.; Latchem, C. Exploring Four Decades of Research in Computers & Education. *Comput. Educ.* **2018**, *122*, 136–152. [CrossRef]
13. Hughes, J.; Thomas, R.; Scharber, C. Assessing Technology Integration: The RAT–Replacement, Amplification, and Transformation-Framework. In Proceedings of the Society for Information Technology & Teacher Education International Conference, Orlando, FL, USA, 19 March 2006; Association for the Advancement of Computing in Education (AACE): Waynesville, NC, USA, 2006; pp. 1616–1620.
14. Robinson, R.; Molenda, M.; Rezabek, L. Facilitating Learning. In *Educational Technology*; Routledge: London, UK, 2013; pp. 27–60.
15. National Research Council. *Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century*; National Academies Press: Washington, DC, USA, 2012. [CrossRef]
16. Akçayır, M.; Akçayır, G. Advantages and Challenges Associated with Augmented Reality for Education: A Systematic Review of the Literature. *Educ. Res. Rev.* **2017**, *20*, 1–11. [CrossRef]
17. Wu, H.-K.; Lee, S.W.-Y.; Chang, H.-Y.; Liang, J.-C. Current Status, Opportunities and Challenges of Augmented Reality in Education. *Comput. Educ.* **2013**, *62*, 41–49. [CrossRef]
18. Nah, F.F.-H.; Zeng, Q.; Telaprolu, V.R.; Ayyappa, A.P.; Eschenbrenner, B. Gamification of Education: A Review of Literature. In *Lecture Notes in Computer Science*; Springer International Publishing: Cham, Switzerland, 2014; pp. 401–409. [CrossRef]
19. Majuri, J.; Koivisto, J.; Hamari, J. Gamification of Education and Learning: A Review of Empirical Literature. In Proceedings of the 2nd International GamiFIN Conference, Pori, Finland, 21–23 May 2018.
20. Burbules, N.C.; Callister, T.A. *Watch IT: The Risks and Promises of Information Technologies for Education*; Routledge: London, UK, 2018.
21. Ratten, V.; Jones, P. Covid-19 and Entrepreneurship Education: Implications for Advancing Research and Practice. *Int. J. Manag. Educ.* **2021**, *19*, 100432. [CrossRef]
22. Caudell, T.P.; Mizell, D.W. Augmented Reality: An Application of Heads-up Display Technology to Manual Manufacturing Processes. In Proceedings of the Twenty-Fifth Hawaii International Conference on System Sciences, Kauai, HI, USA, 7–10 January 1992; IEEE: Piscataway, NJ, USA, 1992; Volume 2, pp. 659–669. [CrossRef]
23. Azuma, R.T. A Survey of Augmented Reality. *Presence Teleoperators Virtual Environ.* **1997**, *6*, 355–385. [CrossRef]
24. Johnson, L.; Levine, A.; Smith, R.; Stone, S. *The 2010 Horizon Report*; New Media Consortium: Austin, TX, USA, 2010.
25. Carmigniani, J.; Furht, B.; Anisetti, M.; Ceravolo, P.; Damiani, E.; Ivkovic, M. Augmented Reality Technologies, Systems and Applications. *Multimed. Tools Appl.* **2011**, *51*, 341–377. [CrossRef]
26. Lee, K. Augmented Reality in Education and Training. *TechTrends* **2012**, *56*, 13–21. [CrossRef]
27. Chen, P.; Liu, X.; Cheng, W.; Huang, R. A Review of Using Augmented Reality in Education from 2011 to 2016. *Innov. Smart Learn.* **2017**, 13–18. [CrossRef]
28. Lampropoulos, G.; Keramopoulos, E.; Diamantaras, K. Enhancing the Functionality of Augmented Reality Using Deep Learning, Semantic Web and Knowledge Graphs: A Review. *Vis. Inform.* **2020**, *4*, 32–42. [CrossRef]

29. Lampropoulos, G.; Keramopoulos, E.; Diamantaras, K. Semantically Enriched Augmented Reality Applications: A Proposed System Architecture and a Case Study. *Int. J. Recent Contrib. Eng. Sci. IT Ijes* **2022**, *10*, 29–46. [CrossRef]
30. Kesim, M.; Ozarslan, Y. Augmented Reality in Education: Current Technologies and the Potential for Education. *Procedia-Soc. Behav. Sci.* **2012**, *47*, 297–302. [CrossRef]
31. Hincapie, M.; Diaz, C.; Valencia, A.; Contero, M.; Güemes-Castorena, D. Educational Applications of Augmented Reality: A Bibliometric Study. *Comput. Electr. Eng.* **2021**, *93*, 107289. [CrossRef]
32. Goff, E.E.; Mulvey, K.L.; Irvin, M.J.; Hartstone-Rose, A. Applications of Augmented Reality in Informal Science Learning Sites: A Review. *J. Sci. Educ. Technol.* **2018**, *27*, 433–447. [CrossRef]
33. Bacca-Acosta, J.L.; Baldiris, S.; Fabregat, R.; Graf, S.; Kinshuk. Augmented Reality Trends in Education: A Systematic Review of Research and Applications. *J. Educ. Technol. Soc.* **2014**, *17*, 133–149.
34. Karakus, M.; Ersozlu, A.; Clark, A.C. Augmented Reality Research in Education: A Bibliometric Study. *EURASIA J. Math. Sci. Technol. Educ.* **2019**, *15*, em1755. [CrossRef]
35. Sirakaya, M.; Alsancak-Sırakaya, D. Trends in Educational Augmented Reality Studies: A Systematic Review. *Malays. Online J. Educ. Technol.* **2018**, *6*, 60–74. [CrossRef]
36. López-Belmonte, J.; Moreno-Guerrero, A.-J.; López Núñez, J.A.; Pozo Sánchez, S. Analysis of the Productive, Structural, and Dynamic Development of Augmented Reality in Higher Education Research on the Web of Science. *Appl. Sci.* **2019**, *9*, 5306. [CrossRef]
37. López-Belmonte, J.; Moreno-Guerrero, A.-J.; López-Núñez, J.-A.; Hinojo-Lucena, F.-J. Augmented Reality in Education. A Scientific Mapping in Web of Science. *Interact. Learn. Environ.* **2020**, 1–15. [CrossRef]
38. Avila-Garzon, C.; Bacca-Acosta, J.; Kinshuk; Duarte, J.; Betancourt, J. Augmented Reality in Education: An Overview of Twenty-Five Years of Research. *Contemp. Educ. Technol.* **2021**, *13*, ep302. [CrossRef]
39. Alvarez-Marin, A.; Velazquez-Iturbide, J.A. Augmented Reality and Engineering Education: A Systematic Review. *IEEE Trans. Learn. Technol.* **2021**, *14*, 817–831. [CrossRef]
40. Mystakidis, S.; Christopoulos, A.; Pellas, N. A Systematic Mapping Review of Augmented Reality Applications to Support STEM Learning in Higher Education. *Educ. Inf. Technol.* **2021**, *27*, 1883–1927. [CrossRef]
41. Billinghurst, M.; Kato, H.; Poupyrev, I. The Magicbook-Moving Seamlessly Between Reality and Virtuality. *IEEE Comput. Graph. Appl.* **2001**, *21*, 6–8. [CrossRef]
42. Martín-Gutiérrez, J.; Fabiani, P.; Benesova, W.; Meneses, M.D.; Mora, C.E. Augmented Reality to Promote Collaborative and Autonomous Learning in Higher Education. *Comput. Hum. Behav.* **2015**, *51*, 752–761. [CrossRef]
43. Lin, C.-Y.; Chai, H.-C.; Wang, J.; Chen, C.-J.; Liu, Y.-H.; Chen, C.-W.; Lin, C.-W.; Huang, Y.-M. Augmented Reality in Educational Activities for Children with Disabilities. *Displays* **2016**, *42*, 51–54. [CrossRef]
44. Fidan, M.; Tuncel, M. Integrating Augmented Reality into Problem Based Learning: The Effects on Learning Achievement and Attitude in Physics Education. *Comput. Educ.* **2019**, *142*, 103635. [CrossRef]
45. Chen, C.; Wang, C.-H. Employing Augmented-Reality-Embedded Instruction to Disperse the Imparities of Individual Differences in Earth Science Learning. *J. Sci. Educ. Technol.* **2015**, *24*, 835–847. [CrossRef]
46. Gavish, N.; Gutiérrez, T.; Webel, S.; Rodríguez, J.; Peveri, M.; Bockholt, U.; Tecchia, F. Evaluating Virtual Reality and Augmented Reality Training for Industrial Maintenance and Assembly Tasks. *Interact. Learn. Environ.* **2015**, *23*, 778–798. [CrossRef]
47. Radu, I. Why Should My Students Use AR? A Comparative Review of the Educational Impacts of Augmented-Reality. In Proceedings of the 2012 IEEE international symposium on mixed and augmented reality (ISMAR), Atlanta, GA, USA, 5–8 November 2012; IEEE: Piscataway, NJ, USA, 2012; pp. 313–314. [CrossRef]
48. Di Serio, Á.; Ibáñez, M.B.; Kloos, C.D. Impact of an Augmented Reality System on Students' Motivation for a Visual Art Course. *Comput. Educ.* **2013**, *68*, 586–596. [CrossRef]
49. Chiang, T.H.; Yang, S.J.; Hwang, G.-J. An Augmented Reality-Based Mobile Learning System to Improve Students' Learning Achievements and Motivations in Natural Science Inquiry Activities. *J. Educ. Technol. Soc.* **2014**, *17*, 352–365.
50. Coimbra, M.T.; Cardoso, T.; Mateus, A. Augmented Reality: An Enhancer for Higher Education Students in Math's Learning? *Procedia Comput. Sci.* **2015**, *67*, 332–339. [CrossRef]
51. Ozdemir, M.; Sahin, C.; Arcagok, S.; Demir, M.K. The Effect of Augmented Reality Applications in the Learning Process: A Meta-Analysis Study. *Eurasian J. Educ. Res.* **2018**, *18*, 165–186. [CrossRef]
52. Khan, T.; Johnston, K.; Ophoff, J. The Impact of an Augmented Reality Application on Learning Motivation of Students. *Adv. Hum. -Comput. Interact.* **2019**, *2019*, 7208494. [CrossRef]
53. Ibáñez, M.B.; Portillo, A.U.; Cabada, R.Z.; Barrón, M.L. Impact of Augmented Reality Technology on Academic Achievement and Motivation of Students from Public and Private Mexican Schools. A Case Study in a Middle-School Geometry Course. *Comput. Educ.* **2020**, *145*, 103734. [CrossRef]
54. Sahin, D.; Yilmaz, R.M. The Effect of Augmented Reality Technology on Middle School Students' Achievements and Attitudes Towards Science Education. *Comput. Educ.* **2020**, *144*, 103710. [CrossRef]
55. Sotiriou, S.; Bogner, F.X. Visualizing the Invisible: Augmented Reality as an Innovative Science Education Scheme. *Adv. Sci. Lett.* **2008**, *1*, 114–122. [CrossRef]
56. Yuen, S.C.-Y.; Yaoyuneyong, G.; Johnson, E. Augmented Reality: An Overview and Five Directions for AR in Education. *J. Educ. Technol. Dev. Exch.* **2011**, *4*, 11. [CrossRef]

57. Cheng, K.-H.; Tsai, C.-C. Affordances of Augmented Reality in Science Learning: Suggestions for Future Research. *J. Sci. Educ. Technol.* **2013**, *22*, 449–462. [CrossRef]
58. Cabero-Almenara, J.; Barroso-Osuna, J. The Educational Possibilities of Augmented Reality. *J. New Approaches Educ. Res.* **2016**, *5*, 44–50. [CrossRef]
59. Alkhattabi, M. Augmented Reality as e-Learning Tool in Primary Schools' Education: Barriers to Teachers' Adoption. *Int. J. Emerg. Technol. Learn. Ijet* **2017**, *12*, 91. [CrossRef]
60. Iatsyshyn, A.; Kovach, V.; Romanenko, Y.; Deinega, I.; Iatsyshyn, A.; Popov, O.; Kutsan, Y.; Artemchuk, V.; Burov, O.; Lytvynova, S. Application of Augmented Reality Technologies for Preparation of Specialists of New Technological Era. In Proceedings of the 2nd International Workshop on Augmented Reality in Education, Kryvyi Rih, Ukraine, 22 March 2019; pp. 181–200.
61. Garzón, J.; Kinshuk; Baldiris, S.; Gutiérrez, J.; Pavón, J. How Do Pedagogical Approaches Affect the Impact of Augmented Reality on Education? A Meta-Analysis and Research Synthesis. *Educ. Res. Rev.* **2020**, *31*, 100334. [CrossRef]
62. Bower, M.; Howe, C.; McCredie, N.; Robinson, A.; Grover, D. Augmented Reality in Education–Cases, Places and Potentials. *Educ. Media Int.* **2014**, *51*, 1–15. [CrossRef]
63. Garzón, J.; Pavón, J.; Baldiris, S. Systematic Review and Meta-Analysis of Augmented Reality in Educational Settings. *Virtual Real.* **2019**, *23*, 447–459. [CrossRef]
64. Cai, S.; Wang, X.; Chiang, F.-K. A Case Study of Augmented Reality Simulation System Application in a Chemistry Course. *Comput. Hum. Behav.* **2014**, *37*, 31–40. [CrossRef]
65. Ibáñez, M.-B.; Delgado-Kloos, C. Augmented Reality for STEM Learning: A Systematic Review. *Comput. Educ.* **2018**, *123*, 109–123. [CrossRef]
66. Sırakaya, M.; Alsancak-Sırakaya, D. Augmented Reality in STEM Education: A Systematic Review. *Interact. Learn. Environ.* **2020**, 1–14. [CrossRef]
67. Osadchyi, V.; Valko, N.; Kuzmich, L. Using Augmented Reality Technologies for STEM Education Organization. In *Journal of Physics: Conference Series*; IOP Publishing Ltd.: Bristol, UK, 2021; Volume 1840, p. 012027. [CrossRef]
68. Gargrish, S.; Mantri, A.; Kaur, D.P. Augmented Reality-Based Learning Environment to Enhance Teaching-Learning Experience in Geometry Education. *Procedia Comput. Sci.* **2020**, *172*, 1039–1046. [CrossRef]
69. Irwansyah, F.S.; Yusuf, Y.; Farida, I.; Ramdhani, M.A. Augmented Reality (AR) Technology on the Android Operating System in Chemistry Learning. In *IOP Conference Series: Materials Science and Engineering*; IOP Publishing: Ltd: Bristol, UK, 2018; Volume 288, p. 012068. [CrossRef]
70. Zhang, J.; Sung, Y.-T.; Hou, H.-T.; Chang, K.-E. The Development and Evaluation of an Augmented Reality-Based Armillary Sphere for Astronomical Observation Instruction. *Comput. Educ.* **2014**, *73*, 178–188. [CrossRef]
71. Carlson, K.J.; Gagnon, D.J. Augmented Reality Integrated Simulation Education in Health Care. *Clin. Simul. Nurs.* **2016**, *12*, 123–127. [CrossRef]
72. Eckert, M.; Volmerg, J.S.; Friedrich, C.M. Augmented Reality in Medicine: Systematic and Bibliographic Review. *JMIR Mhealth Uhealth* **2019**, *7*, e10967. [CrossRef]
73. Tang, K.S.; Cheng, D.L.; Mi, E.; Greenberg, P.B. Augmented Reality in Medical Education: A Systematic Review. *Can. Med. Educ. J.* **2020**, *11*, e81. [CrossRef]
74. Ma, M.; Fallavollita, P.; Seelbach, I.; Von Der Heide, A.M.; Euler, E.; Waschke, J.; Navab, N. Personalized Augmented Reality for Anatomy Education. *Clin. Anat.* **2016**, *29*, 446–453. [CrossRef] [PubMed]
75. Chang, K.-E.; Zhang, J.; Huang, Y.-S.; Liu, T.-C.; Sung, Y.-T. Applying Augmented Reality in Physical Education on Motor Skills Learning. *Interact. Learn. Environ.* **2020**, *28*, 685–697. [CrossRef]
76. Soltani, P.; Morice, A.H. Augmented Reality Tools for Sports Education and Training. *Comput. Educ.* **2020**, *155*, 103923. [CrossRef]
77. Turan, Z.; Meral, E.; Sahin, I.F. The Impact of Mobile Augmented Reality in Geography Education: Achievements, Cognitive Loads and Views of University Students. *J. Geogr. High. Educ.* **2018**, *42*, 427–441. [CrossRef]
78. Serafin, S.; Adjorlu, A.; Nilsson, N.; Thomsen, L.; Nordahl, R. Considerations on the Use of Virtual and Augmented Reality Technologies in Music Education. In Proceedings of the 2017 IEEE virtual reality workshop on k-12 embodied learning through virtual & augmented reality (KELVAR), Los Angeles, CA, USA, 19 March 2017; IEEE: Piscataway, NJ, USA, 2017. [CrossRef]
79. Sermet, Y.; Demir, I. Virtual and Augmented Reality Applications for Environmental Science Education and Training. In *New Perspectives on Virtual and Augmented Reality*; Routledge: London, UK, 2020; pp. 261–275. [CrossRef]
80. Liu, P.-H.E.; Tsai, M.-K. Using Augmented-Reality-Based Mobile Learning Material in EFL English Composition: An Exploratory Case Study. *Br. J. Educ. Technol.* **2013**, *44*, 1–4. [CrossRef]
81. Perry, B. Gamifying French Language Learning: A Case Study Examining a Quest-Based, Augmented Reality Mobile Learning-Tool. *Procedia Soc. Behav. Sci.* **2015**, *174*, 2308–2315. [CrossRef]
82. Challenor, J.; Ma, M. A Review of Augmented Reality Applications for History Education and Heritage Visualisation. *Multimodal Technol. Interact.* **2019**, *3*, 39. [CrossRef]
83. Ibañez-Etxeberria, A.; Gómez-Carrasco, C.J.; Fontal, O.; García-Ceballos, S. Virtual Environments and Augmented Reality Applied to Heritage Education. An Evaluative Study. *Appl. Sci.* **2020**, *10*, 2352. [CrossRef]
84. Radosavljevic, S.; Radosavljevic, V.; Grgurovic, B. The Potential of Implementing Augmented Reality into Vocational Higher Education Through Mobile Learning. *Interact. Learn. Environ.* **2018**, *28*, 404–418. [CrossRef]
85. Landers, R.N. Developing a Theory of Gamified Learning. *Simul. Gaming* **2014**, *45*, 752–768. [CrossRef]

86. Nacke, L.E.; Deterding, S. The Maturing of Gamification Research. *Comput. Hum. Behav.* **2017**, *71*, 450–454. [CrossRef]
87. Deterding, S.; Dixon, D.; Khaled, R.; Nacke, L. From Game Design Elements to Gamefulness. In Proceedings of the 15th international academic MindTrek conference on envisioning future media environments—MindTrek' 11, Tampere, Finland, 28–30 September 2011; ACM Press: New York, NY, USA, 2011. [CrossRef]
88. Deterding, S.; Sicart, M.; Nacke, L.; O'Hara, K.; Dixon, D. Gamification. Using Game-Design Elements in Non-Gaming Contexts. In Proceedings of the 2011 annual conference extended abstracts on human factors in computing systems—CHI EA '11, Vancouver, BC, Canada, 7–12 May 2011; ACM Press: New York, NY, USA, 2011. [CrossRef]
89. Deterding, S. Gamification: Design for Motivation. *Interactions* **2012**, *19*, 14–17. [CrossRef]
90. Seaborn, K.; Fels, D.I. Gamification in Theory and Action: A Survey. *Int. J. Hum. Comput. Stud.* **2015**, *74*, 14–31. [CrossRef]
91. Kapp, K.M. *The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education*; John Wiley & Sons: New York, NY, USA, 2012.
92. Palomino, P.T.; Toda, A.M.; Oliveira, W.; Cristea, A.I.; Isotani, S. Narrative for Gamification in Education: Why Should You Care? In *2019 IEEE 19th International Conference on Advanced Learning Technologies (ICALT)*; IEEE: Piscataway, NJ, USA, 2019. [CrossRef]
93. Hamari, J.; Koivisto, J.; Sarsa, H. Does Gamification Work?—A Literature Review of Empirical Studies on Gamification. In Proceedings of the 2014 47th Hawaii International Conference on System Sciences, Waikoloa, HI, USA, 6–9 January 2014; IEEE: Piscataway, NJ, USA, 2014. [CrossRef]
94. Kim, S.; Song, K.; Lockee, B.; Burton, J. What Is Gamification in Learning and Education? In *Gamification in Learning and Education*; Springer International Publishing: Cham, Switzerland, 2017; pp. 25–38. [CrossRef]
95. Sitzmann, T. A Meta-analytic Examination of the Instructional Effectiveness of Computer-based Simulation Games. *Pers. Psychol.* **2011**, *64*, 489–528. [CrossRef]
96. Hanus, M.D.; Fox, J. Assessing the Effects of Gamification in the Classroom: A Longitudinal Study on Intrinsic Motivation, Social Comparison, Satisfaction, Effort, and Academic Performance. *Comput. Educ.* **2015**, *80*, 152–161. [CrossRef]
97. Manzano-León, A.; Camacho-Lazarraga, P.; Guerrero, M.A.; Guerrero-Puerta, L.; Aguilar-Parra, J.M.; Trigueros, R.; Alias, A. Between Level up and Game over: A Systematic Literature Review of Gamification in Education. *Sustainability* **2021**, *13*, 2247. [CrossRef]
98. Subhash, S.; Cudney, E.A. Gamified Learning in Higher Education: A Systematic Review of the Literature. *Comput. Hum. Behav.* **2018**, *87*, 192–206. [CrossRef]
99. De Sousa Borges, S.; Durelli, V.H.S.; Reis, H.M.; Isotani, S. A Systematic Mapping on Gamification Applied to Education. In Proceedings of the 29th annual ACM symposium on applied computing, Gyeongju, Korea, 24–28 March 2014; ACM: New York, NY, USA, 2014. [CrossRef]
100. Dicheva, D.; Dichev, C.; Agre, G.; Angelova, G. Gamification in Education: A Systematic Mapping Study. *J. Educ. Technol. Soc.* **2015**, *18*, 75–88.
101. Martí-Parreño, J.; Méndez-Ibáñez, E.; Alonso-Arroyo, A. The Use of Gamification in Education: A Bibliometric and Text Mining Analysis. *J. Comput. Assist. Learn.* **2016**, *32*, 663–676. [CrossRef]
102. Swacha, J. State of Research on Gamification in Education: A Bibliometric Survey. *Educ. Sci.* **2021**, *11*, 69. [CrossRef]
103. Sailer, M.; Homner, L. The Gamification of Learning: A Meta-Analysis. *Educ. Psychol. Rev.* **2019**, *32*, 77–112. [CrossRef]
104. Sanchez, É.; Ney, M.; Labat, J.M. Jeux sérieux Et pédagogie Universitaire: De La Conception à l'évaluation Des Apprentissages. *Rev. Int. Des Technol. En Pédagogie Univ.* **2011**, *8*, 48. [CrossRef]
105. O'Donovan, S. *Gamification of the Games Course*; University of Cape Town: Cape Town, South Africa, 2012.
106. López, P.; Rodrigues-Silva, J.; Alsina, Á. Brazilian and Spanish Mathematics Teachers' Predispositions Towards Gamification in STEAM Education. *Educ. Sci.* **2021**, *11*, 618. [CrossRef]
107. Ortiz, M.; Chiluiza, K.; Valcke, M. Gamification in Higher Education and Stem: A Systematic Review of Literature. In Proceedings of the EDULEARN Proceedings, Barcelona, Spain, 4–6 July 2016; IATED: Valencia, Spain, 2016. [CrossRef]
108. Dehghanzadeh, H.; Fardanesh, H.; Hatami, J.; Talaee, E.; Noroozi, O. Using Gamification to Support Learning English as a Second Language: A Systematic Review. *Comput. Assist. Lang. Learn.* **2019**, *34*, 934–957. [CrossRef]
109. Dehganzadeh, H.; Dehganzadeh, H. Investigating Effects of Digital Gamification-Based Language Learning: A Systematic Review. *J. Engl. Lang. Teach. Learn.* **2020**, *12*, 53–93.
110. Sandrone, S.; Carlson, C. Gamification and Game-Based Education in Neurology and Neuroscience: Applications, Challenges, and Opportunities. *Brain Disord.* **2021**, *1*, 100008. [CrossRef]
111. Nevin, C.R.; Westfall, A.O.; Rodriguez, J.M.; Dempsey, D.M.; Cherrington, A.; Roy, B.; Patel, M.; Willig, J.H. Gamification as a Tool for Enhancing Graduate Medical Education. *Postgrad. Med. J.* **2014**, *90*, 685–693. [CrossRef]
112. McCoy, L.; Lewis, J.H.; Dalton, D. Gamification and Multimedia for Medical Education: A Landscape Review. *J. Osteopath. Med.* **2016**, *116*, 22–34. [CrossRef]
113. Ang, E.T.; Chan, J.M.; Gopal, V.; Shia, N.L. Gamifying Anatomy Education. *Clin. Anat.* **2018**, *31*, 997–1005. [CrossRef]
114. Fernandez-Rio, J.; de las Heras, E.; González, T.; Trillo, V.; Palomares, J. Gamification and Physical Education. Viability and Preliminary Views from Students and Teachers. *Phys. Educ. Sport Pedagog.* **2020**, *25*, 509–524. [CrossRef]
115. Ferriz-Valero, A.; Østerlie, O.; Martínez, S.G.; García-Jaén, M. Gamification in Physical Education: Evaluation of Impact on Motivation and Academic Performance Within Higher Education. *Int. J. Environ. Res. Public Health* **2020**, *17*, 4465. [CrossRef] [PubMed]

116. Kamalodeen, V.J.; Ramsawak-Jodha, N.; Figaro-Henry, S.; Jaggernauth, S.J.; Dedovets, Z. Designing Gamification for Geometry in Elementary Schools: Insights from the Designers. *Smart Learn. Environ.* **2021**, *8*, 36. [CrossRef]
117. Chans, G.M.; Castro, M.P. Gamification as a Strategy to Increase Motivation and Engagement in Higher Education Chemistry Students. *Computers* **2021**, *10*, 132. [CrossRef]
118. Mellor, K.E.; Coish, P.; Brooks, B.W.; Gallagher, E.P.; Mills, M.; Kavanagh, T.J.; Simcox, N.; Lasker, G.A.; Botta, D.; Voutchkova-Kostal, A.; et al. The Safer Chemical Design Game. Gamification of Green Chemistry and Safer Chemical Design Concepts for High School and Undergraduate Students. *Green Chem. Lett. Rev.* **2018**, *11*, 103–110. [CrossRef]
119. Rose, J.A.; O'Meara, J.M.; Gerhardt, T.C.; Williams, M. Gamification: Using Elements of Video Games to Improve Engagement in an Undergraduate Physics Class. *Phys. Educ.* **2016**, *51*, 055007. [CrossRef]
120. Jagušt, T.; Botički, I.; So, H.-J. Examining Competitive, Collaborative and Adaptive Gamification in Young Learners' Math Learning. *Comput. Amp Educ.* **2018**, *125*, 444–457. [CrossRef]
121. Lo, C.K.; Hew, K.F. A Comparison of Flipped Learning with Gamification, Traditional Learning, and Online Independent Study: The Effects on Students' Mathematics Achievement and Cognitive Engagement. *Interact. Learn. Environ.* **2018**, *28*, 464–481. [CrossRef]
122. Barringer, D.F.; Plummer, J.D.; Kregenow, J.; Palma, C. Gamified Approach to Teaching Introductory Astronomy Online. *Phys. Rev. Phys. Educ. Res.* **2018**, *14*, 010140. [CrossRef]
123. Mahat, H.; Hashim, M.; Norkhaidi, S.B.; Nayan, N.; Saleh, Y.; Hamid, N.; Hidayah, N.; Faudzi, N.A.M. The Readiness of Geography Teacher Trainees in Gamification Approach. *Rev. Int. Geogr. Educ. Online* **2021**, *11*, 720–734.
124. Ouariachi, T.; Li, C.-Y.; Elving, W.J.L. Gamification Approaches for Education and Engagement on Pro-Environmental Behaviors: Searching for Best Practices. *Sustainability* **2020**, *12*, 4565. [CrossRef]
125. Jung, C. Gamification for Environment Education Based on the Extended Cooperation. *J. Korea Game Soc.* **2017**, *17*, 37–46. [CrossRef]
126. Rivas, E.S.; Palmero, J.R.; Rodríguez, J.S. Gamification of Assessments in the Natural Sciences Subject in Primary Education. *Educ. Sci. Theory Pract.* **2019**, *19*, 95–111. [CrossRef]
127. Moseikina, M.; Toktamysov, S.; Danshina, S. Modern Technologies and Gamification in Historical Education. *Simul. Gaming* **2022**, *53*, 104687812210759. [CrossRef]
128. Bonacini, E.; Giaccone, S.C. Gamification and Cultural Institutions in Cultural Heritage Promotion: A Successful Example from Italy. *Cult. Trends* **2021**, *31*, 3–22. [CrossRef]
129. Gomes, C.; Figueiredo, M.; Bidarra, J. *Gamification in Teaching Music: Case Study. EduRe'14 - International Virtual Conference on Education, Social and Technological Sciences*; Valencia Polytechnic University: Valencia, Spain, 2014; pp. 1–19.
130. Jayalath, J.; Esichaikul, V. Gamification to Enhance Motivation and Engagement in Blended eLearning for Technical and Vocational Education and Training. *Technol. Knowl. Learn.* **2020**, *27*, 91–118. [CrossRef]
131. Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; et al. The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *Int. J. Surg.* **2021**, *88*, 105906. [CrossRef]
132. Liberati, A. The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *Ann. Intern. Med.* **2009**, *151*, 65–94. [CrossRef]
133. Higgins, J.P.; Thomas, J.; Chandler, J.; Cumpston, M.; Li, T.; Page, M.J.; Welch, V.A. *Cochrane Handbook for Systematic Reviews of Interventions*; John Wiley & Sons: New York, NY, USA, 2019. [CrossRef]
134. Webster, J.; Watson, R.T. Analyzing the Past to Prepare for the Future: Writing a Literature Review. *MIS Q.* **2002**, *26*, xiii–xxiii.
135. Aksnes, D.W.; Sivertsen, G. A Criteria-Based Assessment of the Coverage of Scopus and Web of Science. *J. Data Inf. Sci.* **2019**, *4*, 1–21. [CrossRef]
136. Creswell, J.W.; Clark, V.L.P. *Designing and Conducting Mixed Methods Research*; Sage publications: Thousand Oaks, CA, USA, 2017.
137. Molero, D.; Schez-Sobrino, S.; Vallejo, D.; Glez-Morcillo, C.; Albusac, J. A Novel Approach to Learning Music and Piano Based on Mixed Reality and Gamification. *Multimed. Tools Appl.* **2020**, *80*, 165–186. [CrossRef]
138. Sobandi, B.; Wibawa, S.C.; Triyanto, T.; Syakir, S.; Pandanwangi, A.; Suryadi, S.; Nursalim, A.; Santosa, H. Batik AR Ver.1.0: Augmented Reality Application as Gamification of Batik Design Using Waterfall Method. *J. Phys. Conf. Ser.* **2021**, *1987*, 012021. [CrossRef]
139. Sudarmilah, E.; Irsyadi, F.Y.A.; Purworini, D.; Fatmawati, A.; Haryanti, Y.; Santoso, B.; Bakhtiar, D.N.; Ustia, N. Improving Knowledge about Indonesian Culture with Augmented Reality Gamification. *IOP Conf. Ser. Mater. Sci. Eng.* **2020**, *830*, 1–6. [CrossRef]
140. Ramli, R.Z.; Marobi, N.A.U.; Ashaari, N.S. Microorganisms: Integrating Augmented Reality and Gamification in a Learning Tool. *Int. J. Adv. Comput. Sci. Appl.* **2021**, *12*, 354–359. [CrossRef]
141. Carlos-Chullo, J.D.; Vilca-Quispe, M.; Castro-Gutierrez, E. Voluminis: Mobile Application for Learning Mathematics in Geometry with Augmented Reality and Gamification. In *Communications in Computer and Information Science*; Springer International Publishing: Cham, Switzerland, 2020; pp. 295–304. [CrossRef]
142. Mota, J.S.; Canedo, E.D.; Torres, K.S.; Leao, H.A.T. AssociAR: Gamified Process for the Teaching of Children with Autism Through the Association of Images and Words. In Proceedings of the 2020 IEEE frontiers in education conference (FIE), Uppsala, Sweden, 21–24 October 2020; IEEE: Piscataway, NJ, USA, 2020; pp. 1–8. [CrossRef]

143. Zsigmond, I.; Buhai, A. Augmented Reality in Medical Education, an Empirical Study. In *Computational Science and Its Applications—ICCSA 2021*; Springer International Publishing: Cham, Switzerland, 2021; pp. 631–640. [CrossRef]
144. López-Faican, L.; Jaen, J. EmoFindAR: Evaluation of a Mobile Multiplayer Augmented Reality Game for Primary School Children. *Comput. Educ.* **2020**, *149*, 1–20. [CrossRef]
145. Lin, H.-C.K.; Lin, Y.-H.; Wang, T.-H.; Su, L.-K.; Huang, Y.-M. Effects of Incorporating AR into a Board Game on Learning Outcomes and Emotions in Health Education. *Electronics* **2020**, *9*, 1752. [CrossRef]
146. Aoyama, R.; Tse, H. Using Augmented Reality and Gamification to Make History Field Trips More Engaging for University Students. In Proceedings of the 6th International Conference on Language, Education, Humanities and Innovation 2017, the Interdisciplinary Circle of Science, Arts and Innovation, Singapore, 22–23 April 2017; pp. 142–151.
147. Lee, S.-M.; Park, M. Reconceptualization of the Context in Language Learning with a Location-Based AR App. *Comput. Assist. Lang. Learn.* **2019**, *33*, 936–959. [CrossRef]
148. Lin, H.-C.K.; Lin, Y.-H.; Wang, T.-H.; Su, L.-K.; Huang, Y.-M. Effects of Incorporating Augmented Reality into a Board Game for High School Students' Learning Motivation and Acceptance in Health Education. *Sustainability* **2021**, *13*, 3333. [CrossRef]
149. Silva, F.; Ferreira, R.; Castro, A.; Pinto, P.; Ramos, J. Experiments on Gamification with Virtual and Augmented Reality for Practical Application Learning. In *Methodologies and Intelligent Systems for Technology Enhanced Learning, 11th International Conference*; Springer International Publishing: Cham, Switzerland, 2021; pp. 175–184. [CrossRef]
150. Ying, O.L.; Hipiny, I.; Ujir, H.; Juan, S.F.S. Game-Based Learning Using Augmented Reality. In Proceedings of the 2021 8th international conference on computer and communication engineering (ICCCE), Piscataway, NJ, USA, June, 22–23 June 2021; pp. 344–348. [CrossRef]
151. Perry, B. Gamified Mobile Collaborative Location-Based Language Learning. *Front. Educ.* **2021**, *6*, 1–15. [CrossRef]
152. Korosidou, E.; Bratitsis, T. Gamifying Early Foreign Language Learning. In *Internet of Things, Infrastructures and Mobile Applications*; Springer International Publishing: Cham, Switzerland, 2020; pp. 726–737. [CrossRef]
153. Wommer, F.G.B.; Sepel, L.M.N.; Loreto, E.L.S. Insects GO: A Gaming Activity for Entomology Teaching in Middle School. *Res. Sci. Technol. Educ.* **2021**, 1–15. [CrossRef]
154. Rebollo, C.; Remolar, I.; Rossano, V.; Lanzilotti, R. Multimedia Augmented Reality Game for Learning Math. *Multimed. Tools Appl.* **2021**, *81*, 14851–14868. [CrossRef]
155. Yonemoto, K. Reinforcing International Students' Language Skills for Disaster Preparedness: A Case Study of Gamification That Utilizes Augmented Reality Technology. In *Digital Games and Language Learning*; Bloomsbury Academic: London, UK, 2021; pp. 163–192. [CrossRef]
156. Lu, A.; Wong, C.S.K.; Cheung, R.Y.H.; Im, T.S.W. Supporting Flipped and Gamified Learning with Augmented Reality in Higher Education. *Front. Educ.* **2021**, *6*, 1–11. [CrossRef]
157. Logothetis, I.; Papadourakis, G.; Katsaris, I.; Katsios, K.; Vidakis, N. Transforming Classic Learning Games with the Use of AR: The Case of the Word Hangman Game. In *Learning and Collaboration Technologies: Games and Virtual Environments for Learning*; Springer International Publishing: Cham, Switzerland, 2021; pp. 47–64. [CrossRef]
158. Stefanidi, E.; Korozi, M.; Leonidis, A.; Arampatzis, D.; Antona, M.; Papagiannakis, G. When Children Program Intelligent Environments: Lessons Learned from a Serious AR Game. In Proceedings of the Interaction Design and Children, London, UK, 12–15 June 2021; ACM: New York, NY, USA, 2021. [CrossRef]
159. Ortiz, G.; Garcia-de-Prado, A.; Boubeta-Puig, J.; Cwierz, H. A Mobile Application as Didactic Material to Improve Learning on Distributed Architectures. In Proceedings of the 2020 International Conference on Computational Science and Computational Intelligence (CSCI), Las Vegas, NV, USA, 16–18 December 2020; IEEE: Piscataway, NJ, USA, 2020. [CrossRef]
160. Somakeerthi, D.C.S.; Silva, G.W.I.U.D.; Silva, L.D.T.D.; Chandrasiri, S.; Joseph, J.K. Amazon Biology: An Augmented Reality-Based e-Book for Biology. In Proceedings of the 2020 2nd International Conference on Advancements in Computing (ICAC), Colombo, Sri Lanka, 10–11 December 2020; IEEE: Piscataway, NJ, USA, 2020; pp. 410–415. [CrossRef]
161. Wang, D.; Khambari, M.N.M. An AR-Based Gamified English Course in Vocational College Through Interest-Driven Approach. *Univers. J. Educ. Res.* **2020**, *8*, 132–137. [CrossRef]
162. Thamrongrat, P.; Law, E.L.-C. Analysis of the Motivational Effect of Gamified Augmented Reality Apps for Learning Geometry. In Proceedings of the 32nd Australian Conference on Human-Computer Interaction, Sydney, Australia, 2–4 December 2020; ACM: New York, NY, USA, 2020; pp. 65–77. [CrossRef]
163. Plecher, D.A.; Eichhorn, C.; Seyam, K.M.; Klinker, G. ARsinoë—Learning Egyptian Hieroglyphs with Augmented Reality and Machine Learning. In Proceedings of the 2020 IEEE International Symposium on Mixed and Augmented Reality Adjunct (ISMAR-Adjunct), Piscataway, NJ, USA, 9–13 November 2020; pp. 326–332. [CrossRef]
164. Chagas, J.; Santiago, P.; Conci, A. BN Anatomy an Interactive Augmented Reality System for Learning Bone Anatomy. In Proceedings of the GET 2020: 13th International Conference on Game and Entertainment Technologies, Zagreb, Croatia, 23–25 July 2020; pp. 206–210.
165. Alqahtani, H.; Kavakli-Thorne, M. Design and Evaluation of an Augmented Reality Game for Cybersecurity Awareness (CybAR). *Information* **2020**, *11*, 121. [CrossRef]
166. Dan, W.; Khambari, M.N.M.; Wong, S.L.; Razali, A.B.M. Evaluation of a Gamified Augmented Reality Mobile App to Support English Language Learning Among Non-Native Speakers. In Proceedings of the 28th international conference on computers in education, Asia-Pacific Society for Computers in Education, Virtual, 23–27 November 2020; pp. 1–6.

167. Wolf, M.; Wehking, F.; Söbke, H.; Londong, J. Location-Based Apps in Environmental Engineering Higher Education. In Proceedings of the DELbA 2020: Workshop on Designing and Facilitating Educational Location-Based Applications, Online, 15 September 2020; pp. 1–14.
168. Stefanidi, E.; Arampatzis, D.; Leonidis, A.; Korozi, M.; Antona, M.; Papagiannakis, G. MagiPlay: An Augmented Reality Serious Game Allowing Children to Program Intelligent Environments. In *Transactions on Computational Science XXXVII*; Springer: Berlin/Heidelberg, Germany, 2020; pp. 144–169. [CrossRef]
169. Rodríguez, M.; González, E.J.; González-Miquel, M.; Díaz, I. Motivational Active Learning in Chemical Engineering. In *Computer Aided Chemical Engineering*; Elsevier: Amsterdam, The Netherlands, 2020; pp. 2017–2022. [CrossRef]
170. Schez-Sobrino, S.; Vallejo, D.; Glez-Morcillo, C.; Redondo, M.Á.; Castro-Schez, J.J. RoboTIC: A Serious Game Based on Augmented Reality for Learning Programming. *Multimed. Tools Appl.* **2020**, *79*, 34079–34099. [CrossRef]
171. Durão, N.; Moreira, F.; da Silva Costa Ferreira, M.J.; Pereira, C.S.; Annamalai, N. The State of Mobile Learning Supported by Gamification and Augmented Reality in Higher Education Institutions Across Three Continents. *Rev. EDaPECI* **2020**, *20*, 130–147. [CrossRef]
172. Durão, N.; Moreira, F.; Ferreira, M.J.; Pereira, C.S.; Annamalai, N. A Comparative Study about Mobile Learning with Gamification and Augmented Reality in High Education Institutions Across South Europe, South America, and Asia Countries. In Proceedings of the 2019 14th Iberian Conference on Information Systems and Technologies (CISTI), Coimbra, Portugal, 15 June 2019; IEEE: Piscataway, NJ, USA, 2019; pp. 1–6. [CrossRef]
173. Kang, Y.-S.; Chang, Y.-J. Using an Augmented Reality Game to Teach Three Junior High School Students with Intellectual Disabilities to Improve ATM Use. *J. Appl. Res. Intellect. Disabil.* **2019**, *33*, 409–419. [CrossRef]
174. Patricio, J.M.; Costa, M.C.; Manso, A. A Gamified Mobile Augmented Reality System for the Teaching of Astronomical Concepts. In Proceedings of the 2019 14th Iberian Conference on Information Systems and Technologies (CISTI), Coimbra, Portugal, 15 June 2019; IEEE: Piscataway, NJ, USA, 2019; pp. 1–5. [CrossRef]
175. Gardeli, A.; Vosinakis, S. ARQuest: A Tangible Augmented Reality Approach to Developing Computational Thinking Skills. In Proceedings of the 2019 11th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games), Vienna, Austria, 4–6 September 2019; IEEE: Piscataway, NJ, USA, 2019; pp. 1–8. [CrossRef]
176. Lin, S.Y.; Chen, M.P.; Wang, L.C.; Kao, Y.T.; Zou, D.; Xie, H. Enhancing Low Achievers' EFL Learning with Interactive Digital Technologies. In Proceedings of the 27th International Conference on Computers in Education, ICCE 2019, Kenting, Taiwan, 2–6 December 2019; Asia-Pacific Society for Computers in Education. 2019; pp. 617–623.
177. Choolarb, T.; Premsmith, J.; Wannapiroon, P. Imagineering Gamification Using Interactive Augmented Reality to Develop Digital Literacy Skills. In Proceedings of the 2019 the 3rd International Conference on Digital Technology in Education, Tsuru, Japan, 25–27 October 2019; ACM: New York, NY, USA, 2019; pp. 39–43. [CrossRef]
178. Noor, N.M.; Ismail, M.; Yussof, R.L.; Yusoff, F.H. Measuring Tajweed Augmented Reality-Based Gamification Learning Model (TARGaLM) Implementation for Children in Tajweed Learning. *Pertanika J. Sci. Technol.* **2019**, *27*, 1821–1840.
179. Molloy, W.; Huang, E.; Wunsche, B.C. Mixed Reality Piano Tutor: A Gamified Piano Practice Environment. In Proceedings of the 2019 International Conference on Electronics, Information, and Communication (ICEIC), Auckland, New Zealand, 22–25 January 2019; IEEE: Piscataway, NJ, USA, 2019. [CrossRef]
180. Mei, B.; Yang, S. Nurturing Environmental Education at the Tertiary Education Level in China: Can Mobile Augmented Reality and Gamification Help? *Sustainability* **2019**, *11*, 4292. [CrossRef]
181. Chujitarom, W.; Piriyasurawong, P. The Effect of the STEAM-GAAR Field Learning Model to Enhance Grit. *TEM J* **2019**, *8*, 255–263. [CrossRef]
182. Su, C.-H. The effect of users' behavioral intention on gamification augmented reality in STEM (GAR-STEM) education. *J. Balt. Sci. Educ.* **2019**, *18*, 450–465. [CrossRef]
183. Wei, X.; Yang, G.; Weng, D. The Influence of Mobile Augmented Reality-Based Sandbox Games on Chinese Characters Learning. In *Image and Graphics Technologies and Applications*; Springer: Singapore, 2019; pp. 436–446. [CrossRef]
184. Bell, J.; Cheng, C.; Klautke, H.; Cain, W.; Freer, D.; Hinds, T. A Study of Augmented Reality for the Development of Spatial Reasoning Ability. In Proceedings of the 2018 ASEE Annual Conference & Exposition Proceedings, Salt Lake City, UT, USA, 24–27 June 2018; ASEE Conferences. 2018; pp. 1–14. [CrossRef]
185. Castañeda, M.A.; Guerra, A.M.; Ferro, R. Analysis on the Gamification and Implementation of Leap Motion Controller in the i.e.d. Técnico Industrial de Tocancipá. *Interact. Technol. Smart Educ.* **2018**, *15*, 155–164. [CrossRef]
186. Ati, M.; Kabir, K.; Abdullahi, H.; Ahmed, M. Augmented Reality Enhanced Computer Aided Learning for Young Children. In Proceedings of the 2018 IEEE Symposium on Computer Applications & Industrial Electronics (ISCAIE), Penang, Malaysia, 28–29 April 2018; IEEE: Piscataway, NJ, USA, 2018; pp. 129–133. [CrossRef]
187. Costa, M.C.; Patricio, J.M.; Carranca, J.A.; Farropo, B. Augmented Reality Technologies to Promote STEM Learning. In Proceedings of the 2018 13th Iberian Conference on Information Systems and Technologies (CISTI), Cáceres, Spain, 13–16 June 2018; IEEE: Piscataway, NJ, USA, 2018; pp. 1–4. [CrossRef]
188. Francese, R.; Risi, M.; Siani, R.; Tortora, G. Augmented Treasure Hunting Generator for Edutainment. In Proceedings of the 2018 22nd International Conference Information Visualisation (IV), Fisciano, Italy, 10–13 2018; IEEE: Piscataway, NJ, USA, 2018; pp. 524–529. [CrossRef]

189. Khambari, M.N.M. Blending Gamification and Augmented Reality in XploreRAFE Module: Intriguing Excitement and Promoting Collaborative Learning Among Learners in Higher Education. In Proceedings of the 26th International Conference on Computers in Education, Manila, Philippines, 26–30 November 2018; Asia-Pacific Society for Computers in Education. 2018; pp. 625–630.
190. Janes, C.; Andrews, T.; Adbel-Maguid, M. Designing an Augmented Reality Smartphone Application for the Enhancement of Asthma Care Education. In *Advances in Intelligent Systems and Computing*; Springer International Publishing: Cham, Switzerland, 2018; pp. 11–17. [CrossRef]
191. Plecher, D.A.; Eichhorn, C.; Kindl, J.; Kreisig, S.; Wintergerst, M.; Klinker, G. Dragon Tale—A Serious Game for Learning Japanese Kanji. In Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts, Melbourne, Australia, 28–31 October 2018; ACM: New York, NY, USA, 2018; pp. 577–583. [CrossRef]
192. Abdullah, F.; Kassim, M.H.; Sanusi, A.N.Z.; Tidjani, A.A. Experimenting Technology Enhancement Active Learning with Support of Mobile Device, Gamification and Augmented Reality Application. *Adv. Sci. Lett.* **2018**, *24*, 7871–7875. [CrossRef]
193. Ierache, J.; Mangiarua, N.A.; Becerra, M.E.; Igarza, S. Framework for the Development of Augmented Reality Applications Applied to Education Games. In *Lecture Notes in Computer Science*; Springer International Publishing: Cham, Switzerland, 2018; pp. 340–350. [CrossRef]
194. Ati, M.; Abdullahi, H.; Kabir, K.; Ahmed, M. Implementation of Augmented Reality in the Teaching of Young Children. In *Communications in Computer and Information Science*; Springer International Publishing: Cham, Switzerland, 2018; pp. 287–297. [CrossRef]
195. Buzko, V.L.; Bonk, A.V.; Tron, V.V. Implementation of Gamification and Elements of Augmented Reality During the Binary Lessons in a Secondary School. *Educ. Dimens.* **2018**, *51*, 74–83. [CrossRef]
196. Pombo, L.; Marques, M.M. The EduPARK Mobile Augmented Reality Game: Learning Value and Usability. In Proceedings of the 14th International Conference Mobile Learning, Lisbon, Portugal, 14–16 April 2018; International Associationn for Development of the Information Society (IADIS). 2018; pp. 23–30.
197. Song, D.; Xu, H.; Yu, T.; Tavares, A. An Enjoyable Learning Experience in Personalising Learning Based on Knowledge Management: A Case Study. *EURASIA J. Math. Sci. Technol. Educ.* **2017**, *13*, 3001–3008. [CrossRef]
198. Chujitarom, W.; Piriyasurawong, P. Animation Augmented Reality Book Model (AAR Book Model) to Enhance Teamwork. *Int. Educ. Stud.* **2017**, *10*, 59. [CrossRef]
199. Salah, J.; Abdennadher, S.; Atef, S. Galaxy Shop: Projection-Based Numeracy Game for Teenagers with down Syndrome. In *Serious Games*; Springer International Publishing: Cham, Switzerland, 2017; pp. 109–120. [CrossRef]
200. Faisal, S. Gamification of Foreign Language Vocabulary Learning Using Mobile Augmented Reality. *IEEE DOI* **2017**, *10*. [CrossRef]
201. Moreira, F.; Durão, N.; Pereira, C.S.; Ferreira, M.J. Mobile learning with gamification and augmented reality in Portuguese High Education. In Proceedings of the 9th International Conference on Education and New Learning Technologies (EDULEARN17), Barcelona, Spain, 3–5 July 2017; IATED: Valencia, Spain, 2017; pp. 4263–4273. [CrossRef]
202. Pombo, L.; Marques, M.M.; Lucas, M.; Carlos, V.; Loureiro, M.J.; Guerra, C. Moving Learning into a Smart Urban Park: Students' Perceptions of the Augmented Reality EduPARK Mobile Game. *IxDA* **2017**, *35*, 117–134. [CrossRef]
203. Liu, Y.; Holden, D.; Zheng, D. Analyzing Students' Language Learning Experience in an Augmented Reality Mobile Game: An Exploration of an Emergent Learning Environment. *Procedia Soc. Behav. Sci.* **2016**, *228*, 369–374. [CrossRef]
204. Salman, F.H.; Riley, D.R. Augmented Reality Crossover Gamified Design for Sustainable Engineering Education. In Proceedings of the 2016 Future Technologies Conference (FTC), San Francisco, CA, USA, 6–7 December 2016; IEEE: Piscataway, NJ, USA, 2016; pp. 1353–1356. [CrossRef]
205. Brown, T.M.; Smith, T.R.; Gabbard, J.L.; Gilbert, J.E. Augmenting Mathematical Education for Minority Students. In Proceedings of the 2016 IEEE 16th International Conference on Advanced Learning Technologies (ICALT), Austin, TX, USA, 25–28 July 2016; IEEE: Piscataway, NJ, USA, 2016; pp. 260–264. [CrossRef]
206. Bicen, H.; Bal, E. Determination of Student Opinions in Augmented Reality. *World J. Educ. Technol. Curr. Issues* **2016**, *8*, 205–209. [CrossRef]
207. Chen, M.-P.; Liao, B.-C. Augmented Reality Laboratory for High School Electrochemistry Course. In Proceedings of the 2015 IEEE 15th International Conference on Advanced Learning Technologies, Washington, USA, 6–9 July 2015; IEEE: Piscataway, NJ, USA, 2015; pp. 132–136. [CrossRef]
208. Sheng, L.Y. Modelling Learning from Ingress (Google's Augmented Reality Social Game). In Proceedings of the 2013 IEEE 63rd Annual Conference International Council for Education Media (ICEM), Singapore, 1–4 October 2013; IEEE: Piscataway, NJ, USA, 2013; pp. 1–8. [CrossRef]
209. Davis, F.D. User Acceptance of Information Technology: System Characteristics, User Perceptions and Behavioral Impacts. *Int. J. Man-Mach. Stud.* **1993**, *38*, 475–487. [CrossRef]
210. Yusoff, A.F.M.; Romli, A.B. Usability of Mobile Application (Mobile Apps) in The Course of Science, Technology and Engineering in Islam (M-ISTECH) Polytechnis in Malaysia. *Malays. Online J. Educ.* **2018**, *2*, 18–28.
211. Pekrun, R.; Goetz, T.; Frenzel, A.C.; Barchfeld, P.; Perry, R.P. Measuring Emotions in Students' Learning and Performance: The Achievement Emotions Questionnaire (AEQ). *Contemp. Educ. Psychol.* **2011**, *36*, 36–48. [CrossRef]
212. Kiili, K. Digital Game-Based Learning: Towards an Experiential Gaming Model. *Internet High. Educ.* **2005**, *8*, 13–24. [CrossRef]
213. Liang, H.; Xue, Y.L. Understanding Security Behaviors in Personal Computer Usage: A Threat Avoidance Perspective. *J. Assoc. Inf. Syst.* **2010**, *11*, 394–413. [CrossRef]

214. Keller, J.M. The Systematic Process of Motivational Design. *Perform. Instr.* **1987**, *26*, 1–8. [CrossRef]
215. Davis, F.D. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Q.* **1989**, *13*, 319. [CrossRef]
216. Witmer, B.G.; Singer, M.J. Measuring Presence in Virtual Environments: A Presence Questionnaire. *Presence: Teleoperators Virtual Environ.* **1998**, *7*, 225–240. [CrossRef]
217. Wommer, F.G.B.; Loreto, E.M.S.; Sepel, L.M.N.; Loreto, E.L.S. Retracing and Rewriting Hooke's Micrographia Book for Teaching History of Science. *J. Biol. Educ.* **2017**, *52*, 155–165. [CrossRef]
218. Reyes, A.M.; Villegas, O.O.V.; Bojórquez, E.M.; Sánchez, V.G.C.; Nandayapa, M. A Mobile Augmented Reality System to Support Machinery Operations in Scholar Environments. *Comput. Appl. Eng. Educ.* **2016**, *24*, 967–981. [CrossRef]
219. Likert, R. The Method of Constructing an Attitude Scale. In *Readings in Attitude Theory and Measurements*; Fishbein, M., Ed.; John Wiley & Sons: New York, NY, USA, 1967; pp. 90–95.
220. Fu, F.-L.; Su, R.-C.; Yu, S.-C. EGameFlow: A Scale to Measure Learners' Enjoyment of e-Learning Games. *Comput. Educ.* **2009**, *52*, 101–112. [CrossRef]
221. Codish, D.; Ravid, G. Academic Course Gamification: The Art of Perceived Playfulness. *Interdiscip. J. E-Learn. Learn. Objects* **2014**, *10*, 131–151. [CrossRef]
222. Brooke, J. SUS: A Quick and Dirty' Usability Scale. *Usability Eval. Ind.* **1996**, *189*, 4–7.
223. Chau, P.Y.K.; Hu, P.J.-H. Information Technology Acceptance by Individual Professionals: A Model Comparison Approach. *Decis. Sci.* **2001**, *32*, 699–719. [CrossRef]
224. Teo, T. Modelling Technology Acceptance in Education: A Study of Pre-Service Teachers. *Comput. Educ.* **2009**, *52*, 302–312. [CrossRef]
225. Ryan, R.M. Control and Information in the Intrapersonal Sphere: An Extension of Cognitive Evaluation Theory. *J. Personal. Soc. Psychol.* **1982**, *43*, 450–461. [CrossRef]
226. Pearce, J.; Ainley, M.; Howard, S. The Ebb and Flow of Online Learning. *Comput. Hum. Behav.* **2005**, *21*, 745–771. [CrossRef]
227. Pintrich, P.R.; Smith, D.A.D.; Garcia, T.; McKeachie, W.J. *A Manual for the Use of the Motivated Strategies for Learning Questionnaire (MSLQ)*; University of Michigan, National Center for Research to Improve Post-secondary Teaching and Learning: Ann Arbor, MI, USA, 1991.
228. Faragher, R.; Brown, R.I. Numeracy for Adults with down Syndrome: It's a Matter of Quality of Life. *J. Intellect. Disabil. Res.* **2005**, *49*, 761–765. [CrossRef]
229. Caldiera, V.R.B.G.; Rombach, H.D. The Goal Question Metric Approach. *Encycl. Softw. Eng.* **1994**, *2*, 528–532.
230. Hsieh, M.-C.; Kuo, F.-R.; Lin, H.-C.K. The Effect of Employing AR Interactive Approach on Students' English Preposition Learning Performance. *J. Comput. Appl. Sci. Educ.* **2014**, *1*, 45–60.
231. Emerson, R.M.; Fretz, R.I.; Shaw, L.L. *Writing Ethnographic Fieldnotes*; University of Chicago Press: Chicago, IL, USA, 2011.
232. Noor, N.M.; Yussof, R.L.; Yusoff, F.H.; Ismail, M. Gamification and Augmented Reality Utilization for Islamic Content Learning: The Design and Development of Tajweed Learning. In *Communications in Computer and Information Science*; Springer: Singapore, 2018; pp. 163–174. [CrossRef]
233. Laricchia, F. Mobile OS Market Share 2021. In *Statista*. 2022. Available online: https://www.statista.com/statistics/272698/global-market-share-held-by-mobile-operating-systems-since-2009/ (accessed on 13 April 2022).
234. Resnyansky, D. Augmented Reality-Supported Tangible Gamification for Debugging Learning. In Proceedings of the 2020 IEEE International Conference on Teaching, Assessment, and Learning for Engineering (TALE), Piscataway, NJ, USA, 8–11 December; pp. 377–383. [CrossRef]
235. Tóth, R.; Zichar, M.; Hoffmann, M. Improving and Measuring Spatial Skills with Augmented Reality and Gamification. In *Advances in Intelligent Systems and Computing*; Springer International Publishing: Cham, Switzerland, 2020; pp. 755–764. [CrossRef]
236. Nebril, J.; Benito, A.; Nolla, Á. Augmented Reality in Mathematics Education: A Gamification Proposal for Secondary School. In Proceedings of the CIVINEDU Conference 2020: 4th International Virtual Conference on Educational Research and Innovation, 28–9 September 2020; pp. 155–157.
237. Suvajdzic, M.; Oliverio, J.; Barmpoutis, A.; Wood, L.; Burgermeister, P. Discover DaVinci—A Gamified Blockchain Learning App. In Proceedings of the 2020 IEEE International Conference on Blockchain and Cryptocurrency (ICBC), Piscataway, NJ, USA, 3–6 May 2020; pp. 1–2. [CrossRef]
238. Alptekin, M.; Temmen, K. Gamification in an Augmented Reality Based Virtual Preparation Laboratory Training. In *The Challenges of the Digital Transformation in Education*; Springer International Publishing: Cham, Switzerland, 2019; pp. 567–578. [CrossRef]
239. Toth, R.; Zichar, M.; Hoffmann, M. Gamified Mental Cutting Test for Enhancing Spatial Skills. In Proceedings of the 2020 11th IEEE International Conference on Cognitive Infocommunications (CogInfoCom), Piscataway, NJ, USA, 23–25 September 2020; pp. 299–304. [CrossRef]
240. Kiourt, C.; Kalles, D.; Lalos, A.; Papastamatiou, N.; Silitziris, P.; Paxinou, E.; Theodoropoulou, H.; Zafeiropoulos, V.; Papadopoulos, A.; Pavlidis, G. XRLabs: Extended Reality Interactive Laboratories. In Proceedings of the 12th International Conference on Computer Supported Education; SciTePress—Science and Technology Publications: Setúbal, Portugal, 2–4 May 2020. [CrossRef]
241. Argo, A.; Arrigo, M.; Bucchieri, F.; Cappello, F.; Paola, F.D.; Farella, M.; Fucarino, A.; Lanzarone, A.; Bosco, G.L.; Saguto, D.; et al. Augmented Reality Gamification for Human Anatomy. In *Lecture Notes in Computer Science*; Springer International Publishing: Cham, Switzerland, 2019; pp. 409–413. [CrossRef]

242. Sharma, V.; Talukdar, J.; Bhagar, K.K. CodAR: An Augmented Reality Based Game to Teach Programming. In Proceedings of the 27th International Conference on Computers in Education, Kenting, Taiwan, 2–6 December 2019; Asia-Pacific Society for Computers in Education. 2019; pp. 1–3.
243. Cwierz, H.; Díaz-Barrancas, F.; Pardo, P.J.; Guisado, J.I.; Ruiz-Palma, C. Improving programming learning with augmented reality and gamification. In Proceedings of the EDULEARN19 Proceedings, Palma Spain, 1–3 July 2019; IATED: Valencia, Spain, 2019; pp. 1–4. [CrossRef]
244. Deng, L.; Tian, J.; Cornwell, C.; Phillips, V.; Chen, L.; Alsuwaida, A. Towards an Augmented Reality-Based Mobile Math Learning Game System. In *Communications in Computer and Information Science*; Springer International Publishing: Cham, Switzerland, 2019; pp. 217–225. [CrossRef]
245. Hensen, B.; Koren, I.; Klamma, R.; Herrler, A. An Augmented Reality Framework for Gamified Learning. In *Advances in Web-Based Learning—ICWL 2018*; Springer International Publishing: Cham, Switzerland, 2018; pp. 67–76. [CrossRef]
246. Nguyen, N.; Muilu, T.; Dirin, A.; Alamäki, A. An Interactive and Augmented Learning Concept for Orientation Week in Higher Education. *Int. J. Educ. Technol. High. Educ.* **2018**, *15*, 35. [CrossRef]
247. McFadden, C.; Porter, S. Augmented reality escape rooms as high-engagement educational resources. In Proceedings of the ICERI2018 Proceedings, Seville, Spain, 12–14 November 2018; IATED: Valencia, Spain, 2018; pp. 4361–4365. [CrossRef]
248. Rammos, D.; Bratitsis, T. Inclusive Strategies for the History Subject in 6th Grade of Greek Primary School. In Proceedings of the 8th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-Exclusion, Thessaloniki, Greece, 20–22 June 2018; ACM: New York, NY, USA, 2018; pp. 227–233. [CrossRef]
249. Gramajo, M.G.; Lezcano, F.T.; Lobo, S.G.; Juarez, G.; Fraga, A.L. SIMNET: Simulation-Based Exercises for Computer Network Curriculum Through Gamification and Augmented Reality. In Proceedings of the 2018 IEEE World Engineering Education Conference (EDUNINE), Buenos Aires, Argentina, 11–14 March 2018; IEEE: Piscataway, NJ, USA, 2018; pp. 1–5. [CrossRef]
250. Chujitarom, W.; Piriyasurawong, P. STEAM-GAAR Field Learning Model to Enhance Grit. *Int. Educ. Stud.* **2018**, *11*, 23–33. [CrossRef]
251. Flores, P.G.R.; Medina, J.A.M.; Mendivil, E.G.; Villarreal, A.R.V. Using Augmented Reality and Kinect Technologies to Promote Reading Habits. In *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*; Springer International Publishing: Cham, Switzerland, 2018; pp. 75–85. [CrossRef]
252. Zikas, P.; Bachlitzanakis, V.; Papaefthymiou, M.; Kateros, S.; Georgiou, S.; Lydatakis, N.; Papagiannakis, G. Mixed Reality Serious Games and Gamification for Smart Education. In Proceedings of the European conference on games based learning, Academic Conferences International Limited, Paisley, UK, 6–7 October 2016; pp. 805–812.
253. Petrucco, C.; Agostini, D. Teaching Cultural Heritage Using Mobile Augmented Reality. *J. E-Learn. Knowl. Soc.* **2016**, *12*, 115–128.
254. Dita, F.-A. A Foreign Language Learning Application Using Mobile Augmented Reality. *Inform. Econ.* **2016**, *20*, 76–87. [CrossRef]
255. Colpani, R.; Homem, M.R.P. An Innovative Augmented Reality Educational Framework with Gamification to Assist the Learning Process of Children with Intellectual Disabilities. In Proceedings of the 2015 6th international conference on information, intelligence, systems and applications (IISA), Corfu, Greece, 6–8 July 2015; IEEE: Piscataway, NJ, USA, 2015; pp. 1–6. [CrossRef]
256. Shih, D.-T.; Lin, C.L.; Tseng, C.-Y. Combining Digital Archives Content with Serious Game Approach to Create a Gamified Learning Experience. *Int. Arch. Photogramm. Remote Sens. Spat. Inf. Sci.* **2015**, *XL-5/W7*, 387–394. [CrossRef]
257. Eleftheria, C.A.; Charikleia, P.; Iason, C.G.; Athanasios, T.; Dimitrios, T. An Innovative Augmented Reality Educational Platform Using Gamification to Enhance Lifelong Learning and Cultural Education. In Proceedings of the IISA 2013, Piraeus, Greece, 10–12 July 2013; IEEE: Piscataway, NJ, USA, 2013; pp. 1–5. [CrossRef]
258. Eleftheria, A.; Plessa, C.; Chatziparadeisis, I.; Tsolis, D.; Tsakalidis, A. Design and Development of Educational Platform in Augmented Reality Environment Using Gamification to Enhance Traditional, Electronic and Lifelong Learning Experience. In Proceedings of the BCI'13: 6th Balkan Conference in Informatics, Thessaloniki, Greece, 19–21 September 2013; ACM: New York, NY, USA, 2013; pp. 92–95.
259. Ramírez, P.; Ramírez, H.; Infante, L.D.; López, J.M.; Rosquillas, J.; Villegas, A.L.; Santana, D.; Vega, D. de la Explora méxico: A Mobile Application to Learn Mexico's Geography. *Procedia Comput. Sci.* **2013**, *25*, 194–200. [CrossRef]
260. An, Y. A History of Instructional Media, Instructional Design, and Theories. *Int. J. Technol. Educ.* **2021**, *4*, 1–21. [CrossRef]
261. Carlo, G. Augmented Reality and Gamification: A Framework for Developing Supplementary Learning Tool. *Int. J. Comput. Sci. Res.* **2021**, *5*, 595–612. [CrossRef]
262. Mattera, M.; Gava, L.; Urena, R.; Ropero, E. Backing the Right Horse: Gamification and Mixed Realities in Higher Education. In Proceedings of the 2021 the 4th International Conference on Information Science and Systems, Edinburgh, UK, 17–19 March 2021; ACM: New York, NY, USA, 2021; pp. 138–142.
263. Pinto, R.D.; Peixoto, B.; Melo, M.; Cabral, L.; Bessa, M. Foreign Language Learning Gamification Using Virtual Reality-a Systematic Review of Empirical Research. *Educ. Sci.* **2021**, *11*, 222. [CrossRef]
264. Ramírez-Verdugo, M.D.; López, M. Gamification and Augmented Reality to Upgrade Elementary Bilingual Education Students' Health and Engagement. In *Interdisciplinary Approaches toward Enhancing Teacher Education*; IGI Global: Hershey, PA, USA, 2021; pp. 95–118. [CrossRef]
265. Cleto, B. Learning Systems and Gamification. In *Advances in Medical Technologies and Clinical Practice*; IGI Global: Hershey, PA, USA, 2021; pp. 54–67. [CrossRef]

266. Motejlek, J.; Alpay, E. Taxonomy of Virtual and Augmented Reality Applications in Education. *IEEE Trans. Learn. Technol.* **2021**, *14*, 415–429. [CrossRef]
267. Cook, J.; Brown, M.; Sellwood, M.; Campbell, C.; Kouppas, P.; Poronnik, P. XR Game Development as a Tool for Authentic, Experiential, and Collaborative Learning. *Biochem. Mol. Biol. Educ.* **2021**, *49*, 846–847. [CrossRef]
268. Fan, M.; Antle, A.N.; Warren, J.L. Augmented Reality for Early Language Learning: A Systematic Review of Augmented Reality Application Design, Instructional Strategies, and Evaluation Outcomes. *J. Educ. Comput. Res.* **2020**, *58*, 1059–1100. [CrossRef]
269. Bruno, L.E. Get Gamified: Promoting Augmented Reality and Digital Game Technology in Education. In *Augmented Reality Games I*; Springer International Publishing: Cham, Switzerland, 2019; pp. 237–251. [CrossRef]
270. Moreno Martinez, N.M.; Leiva Olivencia, J.J.; Matas Terron, A. Mobile Learning, Gamification and Augmented Reality for the Teaching and Learning of Languages. *Int. J. Educ. Res. Innov. IJERI* **2016**, *6*, 16–34.
271. Chauhan, J.; Taneja, S.; Goel, A. Enhancing MOOC with Augmented Reality, Adaptive Learning and Gamification. In Proceedings of the 2015 IEEE 3rd International Conference on MOOCs, Innovation and Technology in Education (MITE), Amritsar, India, 1–2 October 2015; IEEE: Piscataway, NJ, USA, 2015; pp. 348–353. [CrossRef]
272. Dunleavy, M. Design Principles for Augmented Reality Learning. *TechTrends* **2013**, *58*, 28–34. [CrossRef]
273. Talley, T. *The STEM Coaching Handbook*; Routledge: London, UK, 2016. [CrossRef]
274. Nielsen, J. Why You Only Need to Test with 5 Users. In *Nielsen Norman Group*. 2000. Available online: https://www.nngroup.com/articles/why-you-only-need-to-test-with-5-users/ (accessed on 13 April 2022).
275. Romero, M.; Usart, M.; Ott, M. Can Serious Games Contribute to Developing and Sustaining 21st Century Skills? *Games Cult.* **2014**, *10*, 148–177. [CrossRef]
276. Sung, Y.-T.; Chang, K.-E.; Liu, T.-C. The Effects of Integrating Mobile Devices with Teaching and Learning on Students Learning Performance: A Meta-Analysis and Research Synthesis. *Comput. Educ.* **2016**, *94*, 252–275. [CrossRef]
277. Lally, V.; Sharples, M.; Tracy, F.; Bertram, N.; Masters, S. Researching the Ethical Dimensions of Mobile, Ubiquitous and Immersive Technology Enhanced Learning (MUITEL): A Thematic Review and Dialogue. *Interact. Learn. Environ.* **2012**, *20*, 217–238. [CrossRef]
278. Kearsley, G.; Shneiderman, B. Engagement Theory: A Framework for Technology-Based Teaching and Learning. *Educ. Technol.* **1998**, *38*, 20–23.
279. Dede, C.J.; Jacobson, J.; Richards, J. Introduction: Virtual, Augmented, and Mixed Realities in Education. In *Virtual, Augmented, and Mixed Realities in Education*; Springer: Cham, Switzerland, 2017; pp. 1–16. [CrossRef]
280. Rupp, M.A.; Odette, K.L.; Kozachuk, J.; Michaelis, J.R.; Smither, J.A.; McConnell, D.S. Investigating Learning Outcomes and Subjective Experiences in 360-Degree Videos. *Comput. Educ.* **2019**, *128*, 256–268. [CrossRef]
281. Romasz, T.E.; Kantor, J.H.; Elias, M.J. Implementation and Evaluation of Urban School-Wide Social-Emotional Learning Programs. *Eval. Program Plan.* **2004**, *27*, 89–103. [CrossRef]
282. Johnson, L.; Becker, S.A.; Estrada, V.; Freeman, A. *NMC Horizon Report: 2015 Museum Edition*; The New Media Consortium: Austin, TX, USA, 2015; pp. 1–50.
283. Marín-Díaz, V. The Relationships Between Augmented Reality and Inclusive Education in Higher Education. *Bordón. Rev. Pedagog.* **2017**, *69*, 125. [CrossRef]
284. Simões, J.; Redondo, R.D.; Vilas, A.F. A Social Gamification Framework for a k-6 Learning Platform. *Comput. Hum. Behav.* **2013**, *29*, 345–353. [CrossRef]
285. Dede, C. Immersive Interfaces for Engagement and Learning. *Science* **2009**, *323*, 66–69. [CrossRef] [PubMed]
286. Shapley, K.; Sheehan, D.; Maloney, C.; Caranikas-Walker, F. Effects of Technology Immersion on Middle School Students' Learning Opportunities and Achievement. *J. Educ. Res.* **2011**, *104*, 299–315. [CrossRef]
287. Beck, D. Augmented and Virtual Reality in Education: Immersive Learning Research. *J. Educ. Comput. Res.* **2019**, *57*, 1619–1625. [CrossRef]
288. Brown, J.S.; Collins, A.; Duguid, P. Situated Cognition and the Culture of Learning. *Educ. Res.* **1989**, *18*, 32–42. [CrossRef]
289. Kolb, D.A. *Experiential Learning: Experience as the Source of Learning and Development*; FT Press: Upper Saddle River, NJ, USA, 2014.
290. Jonassen, D.H. Thinking Technology: Toward a Constructivist View of Instructional Design. *Educ. Technol.* **1990**, *30*, 32–34.
291. Roseth, C.J.; Johnson, D.W.; Johnson, R.T. Promoting Early Adolescents' Achievement and Peer Relationships: The Effects of Cooperative, Competitive, and Individualistic Goal Structures. *Psychol. Bull.* **2008**, *134*, 223–246. [CrossRef]
292. Sharan, Y. Cooperative Learning for Academic and Social Gains: Valued Pedagogy, Problematic Practice. *Eur. J. Educ.* **2010**, *45*, 300–313. [CrossRef]
293. Prodromou, T. *Augmented Reality in Educational Settings*; Brill: Leiden, The Netherlands, 2019.
294. Gimbert, B.; Cristol, D. Teaching Curriculum with Technology: Enhancing Children's Technological Competence During Early Childhood. *Early Child. Educ. J.* **2003**, *31*, 207–216. [CrossRef]
295. Rajanen, M.; Rajanen, D. Usability Benefits in Gamification. *GamiFIN* **2017**, *87*, 95.
296. Hamari, J.; Koivisto, J. Working Out for Likes: An Empirical Study on Social Influence in Exercise Gamification. *Comput. Hum. Behav.* **2015**, *50*, 333–347. [CrossRef]
297. Liu, D.; Santhanam, R.; Webster, J. Toward Meaningful Engagement: A Framework for Design and Research of Gamified Information Systems. *MIS Q.* **2017**, *41*, 1011–1034. [CrossRef]

298. Rodrigues, L.F.; Costa, C.J.; Oliveira, A. How Gamification Can Influence the Web Design and the Customer to Use the e-Banking Systems. In Proceedings of the International Conference on Information Systems and Design of Communication—ISDOC'14, Lisbon, Portugal, 16–17 May 2014; ACM Press: New York, NY, USA, 2014. [CrossRef]
299. Huotari, K.; Hamari, J. A Definition for Gamification: Anchoring Gamification in the Service Marketing Literature. *Electron. Mark.* **2016**, *27*, 21–31. [CrossRef]
300. Kiryakova, G.; Angelova, N.; Yordanova, L. Gamification in Education. In Proceedings of the 9th International Balkan Education and Science Conference, Edirne, Turkey, 16–18 October 2014.
301. Sweetser, P.; Wyeth, P. GameFlow: A Model for Evaluating Player Enjoyment in Games. *Comput. Entertain.* **2005**, *3*, 3. [CrossRef]
302. Haugstvedt, A.-C.; Krogstie, J. Mobile Augmented Reality for Cultural Heritage: A Technology Acceptance Study. In Proceedings of the 2012 IEEE international symposium on mixed and augmented reality (ISMAR), Atlanta, GA, USA, 5–8 November 2012; IEEE: Piscataway, NJ, USA, 2012. [CrossRef]
303. Tan, W.H. *Gamifikasi Dalam Pendidikan Pembelajaran Berasaskan Permainan*; Penerbit Universiti Sultan Idris: Tanjung Malim, Malaysia, 2015.
304. Mayer, R.; Mayer, R.E. *The Cambridge Handbook of Multimedia Learning*; Cambridge University Press: Cambridge, UK, 2005.
305. Zichermann, G.; Cunningham, C. *Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps*; O'Reilly Media, Inc.: Sebastopol, CA, USA, 2011.
306. Malone, T.W.; Lepper, M.R. Making Learning Fun: A Taxonomy of Intrinsic Motivations for Learning. *Aptitude, Learning, and Instruction* **1987**, 223–254.
307. Georgiou, Y.; Kyza, E.A. Relations Between Student Motivation, Immersion and Learning Outcomes in Location-Based Augmented Reality Settings. *Comput. Hum. Behav.* **2018**, *89*, 173–181. [CrossRef]
308. Swartout, W.; van Lent, M. Making a Game of System Design. *Commun. ACM* **2003**, *46*, 32–39. [CrossRef]
309. Crocco, F.; Offenholley, K.; Hernandez, C. A Proof-of-Concept Study of Game-Based Learning in Higher Education. *Simul. Gaming* **2016**, *47*, 403–422. [CrossRef]
310. Pozo-Sánchez, S.; Lampropoulos, G.; López-Belmonte, J. Comparing Gamification Models in Higher Education Using Face-to-Face and Virtual Escape Rooms. *J. New Approaches Educ. Res.* **2022**, *2*, 1–16. [CrossRef]
311. Sylwester, R. How Emotions Affect Learning. *Educ. Leadersh.* **1994**, *52*, 60–65.
312. Barab, S.; Zuiker, S.; Warren, S.; Hickey, D.; Ingram-Goble, A.; Kwon, E.-J.; Kouper, I.; Herring, S.C. Situationally Embodied Curriculum: Relating Formalisms and Contexts. *Sci. Educ.* **2007**, *91*, 750–782. [CrossRef]
313. El-Masri, M.; Tarhini, A. A Design Science Approach to Gamify Education: From Games to Platforms. In Proceedings of the ECIS 2015 Research-in-Progress Papers, Münster, Germany, 26–29 May 2015.
314. Dondlinger, M.J. Educational Video Game Design: A Review of the Literature. *J. Appl. Educ. Technol.* **2007**, *4*, 21–31.
315. Klopfer, E.; Squire, K. Environmental Detectives—The Development of an Augmented Reality Platform for Environmental Simulations. *Educ. Technol. Res. Dev.* **2007**, *56*, 203–228. [CrossRef]
316. Dunleavy, M.; Dede, C.; Mitchell, R. Affordances and Limitations of Immersive Participatory Augmented Reality Simulations for Teaching and Learning. *J. Sci. Educ. Technol.* **2008**, *18*, 7–22. [CrossRef]
317. Robson, K.; Plangger, K.; Kietzmann, J.H.; McCarthy, I.; Pitt, L. Is It All a Game? Understanding the Principles of Gamification. *Bus. Horiz.* **2015**, *58*, 411–420. [CrossRef]
318. Sharples, M.; de Roock, R.; Ferguson, R.; Gaved, M.; Herodotou, C.; Koh, E.; Kukulska-Hulme, A.; Looi, C.-K.; McAndrew, P.; Rienties, B.; et al. *Innovating Pedagogy 2016: Open University Innovation Report 5*; Institute of Educational Technology, The Open University: Liverpool, UK, 2016.