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Review

Using Serious Games and Digital Games to Improve Students' Computational Thinking and Programming Skills in K-12 Education: A Systematic Literature Review

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Abstract: Computational thinking and problem-solving skills have become vital for students to develop. Digital games and serious games are increasingly being used in educational settings and present great potential to aid students' learning. This study aims to explore the role and impact of serious games and digital games on students' computational thinking and programming skills in primary, secondary, and K-12 education through a systematic review of the existing literature. Four research questions were set to be examined. Following the PRISMA framework, 78 studies deriving from IEEE, Scopus, and Web of Science over the period of 2011–2024 are examined. The studies are categorized into Theoretical and Review studies, Proposal and Showcase studies, and Experimental and Case studies. Based on the results, serious games and digital games arose as meaningful educational tools that are positively viewed by education stakeholders and that can effectively support and improve K-12 education students' computational thinking and programming skills. Among the benefits identified, it was revealed that serious games offer enjoyable and interactive learning experiences that can improve students' learning performance, engagement, and motivation, enhance students' confidence and focus, and promote self-regulated learning and personalized learning. Additionally, serious games emerged as an educational means that can effectively support social learning and provide real-time feedback. The challenges identified were related to the selection of games and the game-related design elements, decisions, and approaches. Hence, the study highlights the significance of the design of serious games and the need to cultivate students' computational thinking, problem-solving, and social skills from a young age. Finally, the study reveals key design principles and aspects to consider when developing serious games and digital games and highlights the need to involve education stakeholders throughout the design and development process.

Keywords: serious games; digital games; digital game-based learning; gamification; computational thinking; programming; computer science; computer education; primary education; secondary education; k-12 education; review

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1. Introduction

Recent societal and economic developments have highlighted the need for educational systems to focus on cultivating students' 21st-century skills [1]. In this context, the development of soft skills is often prioritized over that of hard skills since they better prepare

students for their future careers and roles in society [2] with emphasis being put on students' cognitive, intrapersonal, interpersonal, and technical skills and specifically on their problem-solving skills, critical thinking, communication, collaboration, and creativity [3,4].

Furthermore, in the ever-increasing digitalized world, computational thinking [5] and programming skills [6] are becoming more necessary in the context of 21st-century education. Hence, greater efforts are being made to improve students' development of computational thinking and programming skills in K-12 education, in particular [7,8]. Computational thinking refers to an individual's ability to create creative solutions for complex problems, through algorithmic thinking (systematic and procedural problem solutions), decomposition (deconstruction of problems into smaller and simpler ones), pattern recognition (identification of patterns and motifs within problems), abstraction (focus on the most relevant information while excluding irrelevant details), and debugging (identifying and correcting any errors) [9]. Particularly, computational thinking is defined as an individual's ability to utilize algorithmic processes to effectively solve problems, with or without using digital devices, while capitalizing on computer science concepts [10]. However, although computational thinking is mostly associated with the field of computer science, it constitutes a fundamental skill that can benefit all individuals as it refers to the way humans compute, process, and analyze information [11]. Computational thinking also plays a crucial part in students' programming learning as, besides the ability to code, students can improve their problem-solving skills, their communication and collaboration skills, as well as their creativity and innovative thinking [7]. As programming learning activities can enhance an individual's logical reasoning, it is important for students to be engaged in such activities from a young age and to use programming tools that are tailored to their developmental stage and learning styles [12].

Serious games are increasingly being used in educational settings and show great potential to improve students' computational thinking and programming learning [13,14]. Serious games are games that are designed primarily for educational purposes rather than purely for entertainment reasons [15]. They differ from typical digital games, which are games that can be played using digital devices, which, although focus primarily on users' entertainment and leisure and not on learning, can still be used in educational settings [16,17]. Serious games offer multimodal learning material and interactive interfaces and tasks that increase students' engagement [18] and enable students to enhance their knowledge and skills through their involvement in challenging, interactive, and enjoyable activities [19]. Through their involvement in learning through serious games, increased students' learning motivation and engagement can be achieved, which renders serious games a meaningful educational means [20].

Although there have been previous studies that explored the use of serious games in education while reporting positive learning outcomes [19,21–23], to the best of our knowledge, there has not been any prior study that examined recent works on the use of serious games and digital games while focusing on K-12 education and students' computational thinking and programming skills. Therefore, this study aims to examine the existing literature, following a systematic literature review approach, to identify the role and impact of serious games and digital games on students' computational thinking and programming skills in primary, secondary, and K-12 education. The scope of the study and the research questions (RQs) set to be addressed influenced the variables set to be identified, extracted, and analyzed. Specifically, the main RQs this study strives to address are:

- RQ1: What are the characteristics, specifications, and outcomes of the studies that explored the use of serious games and digital games to support students' computational thinking and programming skills?

- RQ2: What are the main benefits and disadvantages of integrating serious games when focusing on students' computational thinking and programming skills?
- RQ3: How do serious games influence K-12 students' computational thinking and programming skills?
- RQ4: What are the key design aspects and principles?

This study contributes to the existing body of knowledge by analyzing relevant documents up to 2024, categorizing them, examining their specifications, exploring them through a content analysis, revealing the advantages, disadvantages, and general outcomes of integrating serious games and digital games into education, and identifying the key design aspects and principles. The remainder of the study goes over relevant to the topic studies (Section 2) and the methodology followed (Section 3). Additionally, in Section 4, the results of the documents are analyzed, which are divided into the following four parts: (1) Document collection analysis; (2) Theoretical and Review studies analysis; (3) Proposal and Showcase studies analysis; and (4) Experimental and Case studies analysis. The outcomes of this study are further discussed in Section 5 and the conclusions, limitations, and future research directions are presented in Section 6.

2. Related Work

This section aims to provide an overview regarding the use of digital games and serious games in education and the related outcomes while also going over other relevant studies that have explored the use of digital games, game-based learning, and serious games in improving students' computational thinking and programming skills in different educational settings. Research into the use of serious games in education is increasing as they are being more widely adopted and integrated into educational settings [24–26]. Studies have highlighted the role and the benefits of the use of serious games in teaching and learning activities. For example, Zhonggen [19] explored the game features that led to the successful integration of games into classrooms and resulted in positive learning outcomes. Their study provided guidelines to effectively design educational games and highlighted the positive influence that serious games can have on students as these games improve students' engagement, their understanding of concepts, and their knowledge acquisition and long-term retention. Additionally, it was evident that serious games can improve students' cognitive skills and positively affect their motivation, interest, and mood, as well as provide opportunities for collaborative and social learning to occur. However, the authors highlighted that particular emphasis should be put on the design of these games so as not to overload students' mental workload. These outcomes are in line with those of Backlund and Hendrix [21] who focused on examining the effectiveness of educational games. Their findings presented that the vast majority of serious game interventions resulted in students achieving better learning outcomes, increased motivation, and enhanced problem-solving skills. In another systematic literature review study, Conolly et al. [22] looked into the impact of serious games and digital games on students' learning engagement based on empirical data. Based on their results, using such games in educational settings had positive cognitive, behavioral, motivational, and social impacts. Students' knowledge acquisition as well as attentional and visual perceptual skills were also improved.

Girard et al. [23] focused on experimental randomized controlled trial studies that integrated serious games or digital games into educational settings to identify the effectiveness of different applications. The authors highlighted that although serious games can yield positive learning outcomes and positively affect the educational process, there is a clear need for more empirical studies to be conducted to further examine and assess their effectiveness. While focusing on K-12 education, Young et al. [27] examined the use of digital games within the curriculum through a literature review. Different types of

games and simulations used in education were identified and analyzed. Additionally, the study highlighted the need for more empirical and longitudinal studies to be carried out to better understand how to develop appropriate serious games, how to select the most optimal ones for each case, and how serious games can influence teaching and learning practices. The study commented upon the need to include various education stakeholders in the development process to put emphasis on aligning game objectives with learning goals. Finally, it highlighted the importance of considering students' unique characteristics, preferences, and needs.

Due to their versatility and their educational benefits [28], the use of serious games is being examined in different educational contexts, such as science education [29], medical education [30], Mathematics [31], etc. Additionally, recent studies have put emphasis on supporting students' computational thinking and programming skills through gameful approaches. Specifically, Miljanovic and Bradbury [32] focused on exploring serious games that aimed to support students' programming learning. They emphasized the knowledge that these games focus on improving and how they are being assessed. Based on their outcomes, most serious games aim to improve students' knowledge of programming fundamentals and principles. Areas such as algorithms, software design, data structures, and development methods were also examined.

Kazimoglu et al. [33] explored how the use of digital games in education can influence students' computational thinking. The study analyzed existing serious games and focused on how they are being developed, evaluated, and integrated into classrooms. The need to provide in-depth gameplay mechanics and content within games to effectively promote students' computational thinking skills was revealed. They focused on integrating programming constructs and computational skills as parts of the gameplay. The outcomes of their game assessment revealed that students enjoyed playing the game and showcased improved problem-solving skills. In their study, Toukiloglou and Xinogalos [34] examined adaptive support within serious games in the context of programming. The authors highlighted that there is a lack of studies that focus on adaptive support within serious games and that mixed outcomes in terms of their learning effectiveness were reported. Focusing on studies that used serious games to teach object-oriented programming, Abbasi et al. [35] carried out a systematic literature review. Based on their findings, serious games can be used in different ways to support the educational process, such as learning by developing games, learning by playing, and learning through game-related tools. Additionally, the integration of serious games into programming learning can result in positive learning outcomes in terms of cognitive skills, academic performance, and task management. Students who were engaged in the development of serious games also showcased improved problem-solving skills and understanding of the concepts taught.

In another review study, Tatar and Eseryel [36] explored the use of game-based learning to promote K-12 students' computational thinking. The study focused on identifying the impact of game-based learning on students' motivation, engagement, and achievements, revealing the most commonly used methods to assess computational thinking, and understanding the specifications of the learning environments. Their findings highlighted that emphasis is being placed mainly on STEM education and that block-based coding environments are most commonly used. Finally, the assessment methods used are mainly pre-designed programming artifacts or student-created ones and focus on computational thinking concepts, such as abstraction, algorithmic thinking, etc., to solve problems.

The outcomes of the related studies highlight the potential of serious games and gameful approaches to support education and enhance students' programming skills and computational thinking. Education stakeholders express positive views regarding their adoption. However, the related studies do not contain data from the last couple of years.

Additionally, they do not primarily focus on primary education, secondary education, and K-12 education and emphasis is mostly placed on students' learning outcomes and motivation and the positive results of their integration. Some of the studies did not include documents from Scopus or Web of Science (WoS) and others focused on specific aspects of serious games (e.g., adaptive support systems) or specific programming courses (e.g., object-oriented programming). In the existing literature review studies only experimental and case studies are examined. As a result, little is known about the recent advancements in the field regarding the adoption of serious games to support K-12 students' computational thinking and programming skills. Additionally, there is a need to identify the main benefits and challenges of their integration. Finally, little emphasis was put on identifying key design aspects and principles associated with the effective development and integration of serious games in classrooms. Based on the above and given the increasing importance of cultivating students' computational skills from a young age, this study strives to contribute to the field by examining recent literature of highly regarded databases and analyzing Theoretical and Review, Proposal and Show-case, and Experimental and Case studies. Additionally, through an in-depth content analysis, it examines the specifications and characteristics of the existing studies and reveals the advantages, disadvantages, and general outcomes of integrating serious games and digital games to support students' programming skills and computational thinking. Finally, the study identifies the key design aspects and principles associated with the development of effective serious games.

3. Materials and Methods

The integration of serious games in education constitutes an interdisciplinary field of study; hence, to examine its role in and impact on K-12 education, a systematic literature review approach was adopted. Specifically, this approach enables the synthesis of the current knowledge on a topic and the identification of new information contained in the existing literature [37]. To ensure a valid and transparent analysis of the existing literature, the Preferred Reporting Items for Systematic Meta-Analyses (PRISMA) statement [38], which is widely used in similar studies and is regarded as a reliable and rigorous approach [39], was adopted.

Given the scope of this study and the related terms associated with serious games [15], the following query was used to search and identify relevant documents that focused on serious games, K-12 education, programming, and computational thinking: ("video gam*" OR "serious gam*" OR "digital gam*" OR "educational gam*" OR "applied gam*" OR "virtual gam*" OR "online gam*" OR "mobile gam*" OR "immersive gam*") AND ("programming" OR "computational thinking" OR "coding" OR "software engineering") AND ("grade school*" OR "primary education" OR "primary school*" OR "elementary education" OR "elementary school*" OR "secondary education" OR "secondary school*" OR "middle school*" OR "lyceum" OR "high school*" OR "k-12"). The final search was conducted in September 2024 in IEEE, Scopus, and WoS databases. The specific databases were selected due to their being highly regarded, containing relevant and high-quality documents, and being widely used in other similar studies [40,41]. Finally, the only restriction set when searching for the documents was for them to be written in English, with no other restrictions in terms of publication year or publication type to ensure that all relevant documents were examined.

In Figure 1, the complete document identification and processing steps are presented following the PRISMA guidelines. Throughout the steps of the document selection process, both researchers worked independently and cross-checked their decisions. In case there was a disagreement, the results were further discussed. A total of 751 documents were identified from IEEE (n = 185), Scopus (n = 377), and WoS (n = 189). Before the screening,

269 documents were removed as they were identified as duplicates using both automatic and manual processes (n = 215). Additionally, some documents were excluded as they were proceedings (n = 48), erratum (n = 5), or editor notes (n = 1). As a result, 482 documents were screened based on their titles and abstracts. The main inclusion criterion set was for a study to focus on the use of serious games and/or digital games in K-12 education in the context of computational thinking and/or programming. No exclusion criteria were used to ensure that the inclusion of a study in the analysis was solely based on it meeting the inclusion criterion. Hence, for a document to be considered relevant to the topic and be included in the analysis, it had to meet the specific criterion. In total, 381 documents were removed since they did not meet the inclusion criterion and were, thus, deemed out of the study scope. The remaining 101 documents were sought for retrieval. With the exception of one document, which was not retrieved despite the efforts made by searching in academic databases and websites and contacting the authors, the files of the remaining 100 documents were retrieved. Prior to further examining the full-text of the documents, based on the scope of the study and the research questions set, a literature review matrix was created to aid in the identification and extraction of relevant information. Having the literature review matrix prepared, the variables of which are analyzed in Section 4, the full-text of the remaining documents was examined. Twenty documents were removed since they did not meet the inclusion criterion, one document was removed since it was not written in English, and one document was excluded since it was an abstract only. Consequently, 78 documents remained and were included in this analysis.

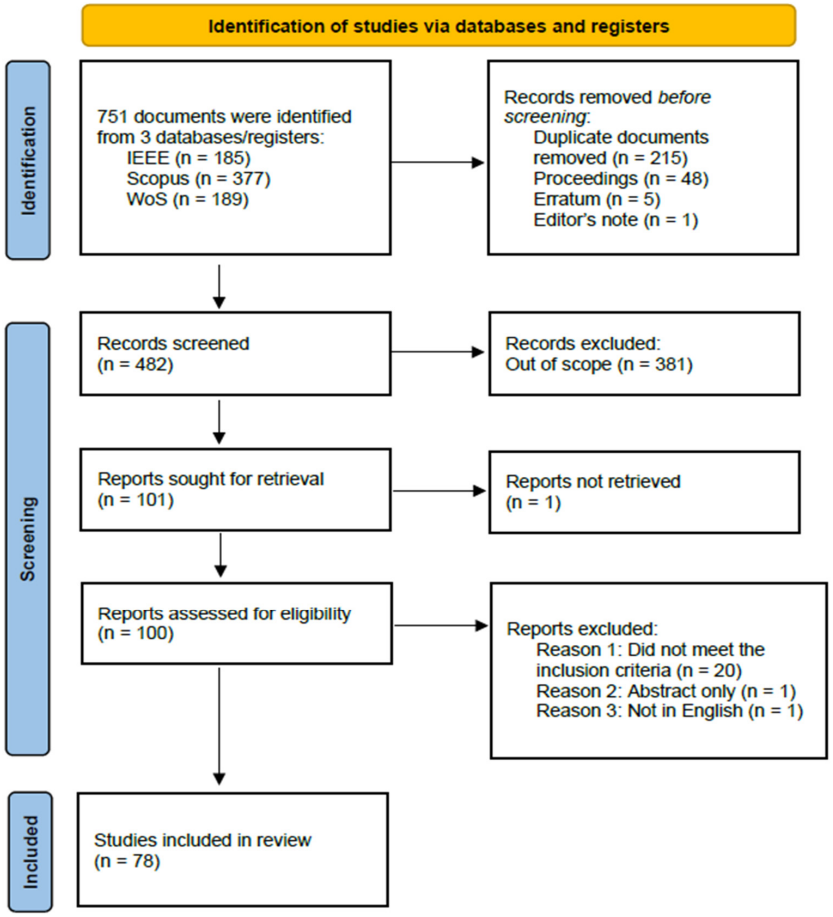


Figure 1. PRISMA flowchart.

4. Result Analysis

The 78 documents were divided into three categories: (1) Theoretical and Review studies: Studies that contributed to the topic but did not present any prototype application or carry out an experiment; (2) Proposal and Showcase studies: Studies that presented and discussed a potential application or game but did not apply or test it in classrooms; and (3) Experimental and Case studies: Studies that applied serious games or digital games in educational contexts and evaluated their impact through the conduct of case studies. As can be seen in Table 1, most documents were Experimental and Case studies (n = 58, 74.3%), followed by Proposal and Showcase studies (n = 11, 14.1%) and Theoretical and Review studies (n = 9, 11.5%).

Table 1. Distribution of the studies examined.

Categories	References
Theoretical and Review studies (n = 9, 11.5%)	[42–50]
Showcase and Proposal studies (n = 11, 14.1%)	[51–61]
Experimental and case studies (n = 58, 74.3%)	[62–119]

The result analysis consists of four parts: (1) Document collection analysis, where all three document categories were examined, focusing on the country, authors per document, document type, publication year, educational level, and sources; (2) Theoretical and Review studies analysis, which focused on examining and summarizing the documents of the specific category; (3) Proposal and Showcase studies analysis, where studies that focused on presenting their proposed applications, games, and prototypes were analyzed and summarized; and (4) Experimental and Case studies analysis, where, given the nature of these documents, a more in-depth content analysis was carried out to analyze the following variables: participants, sample, course details, course type, digital game type, platform and device, closed or open-source, existing or newly developed, game elements, development methodology, experiment type, research methods, evaluation tools, and data analysis methods. Through this analysis, the main characteristics, specifications, and outcomes of the related studies are highlighted. Finally, the study put emphasis on identifying the main advantages, disadvantages, and outcomes described in the literature which are further discussed in the discussion section.

4.1. Document Collection Analysis

To better understand the scope of the studies contained in this analysis and their characteristics, this subsection focuses on analyzing the specifications of the 78 documents examined in the study (RQ1). Initially, based on the three categories set, the number of documents that each country published and their type were explored. The related outcomes are presented in Figure 2. It should be noted that the corresponding author's country was considered, and in the case that no corresponding author was specified, the country of the first author was used. Based on the outcomes, most studies were published by the United States (n = 15, 19.2%), followed by Greece (n = 12, 15.4%). Both Spain and Indonesia published five documents (6.4%), followed by Sweden (n = 4, 5.1%). Hong Kong, Turkey, Estonia, and China all published three documents each (3.8%), while Slovakia, Japan, Israel, Brazil, Malaysia, and Taiwan published two documents each (2.6%). The United States, Greece, Spain, and Indonesia were the countries that contributed the most Experimental and Case studies. Additionally, the United States published the most Proposal and Showcase studies while Greece published the most Theoretical and Review studies.

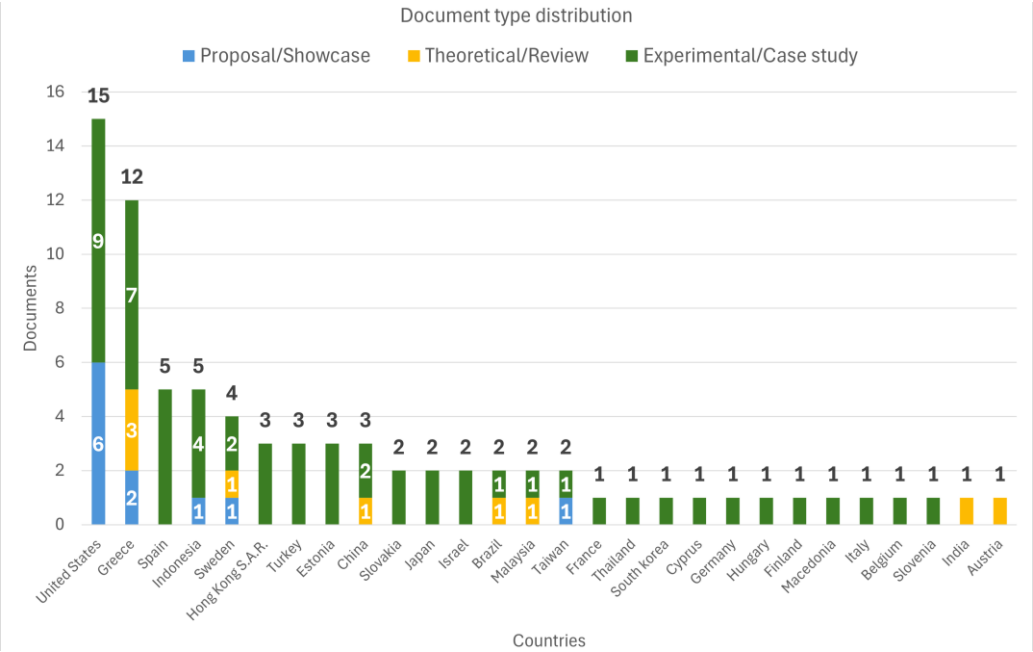


Figure 2. Document type distribution based on country and document type.

From this distribution, it is apparent that authors from various continents and countries focus on this topic. Hence, it can be inferred that there is global interest in examining the use of serious games in educational settings and that their integration into educational settings is examined in various socio-cultural, economic, and educational settings. This fact indicates the potential and importance of serious games and highlights the need to further examine this topic from a multidisciplinary perspective.

Furthermore, the documents were written by 3.42 authors on average and were published in 57 outlets as journal articles, conference papers, and book chapters. Based on the related outcomes, most studies were published as conference/proceedings papers (n = 44, 56.4%), followed by journal articles (n = 32, 41.0%). Only two studies (2.6%) were book chapters. Additionally, "Education and Information technologies" (n = 5), "Journal of Educational Computing Research" (n = 4), and "IEEE Global Engineering Education Conference" (EDUCON) (n = 3) were the outlets with the highest number of published documents in the field, as can be seen in Table 2, which presents the outlets that had at least two relevant published documents.

Given the scope of the study to examine the impact of serious games and digital games on students' computational thinking and programming skills in K-12 education, the educational level, which the studies focused on, was also explored. As can be seen in Figure 3, most studies examined the influence of serious games in primary education (n = 34, 43.6%), followed closely by those focusing on secondary education (n = 28, 35.9%). Additionally, 16 studies (20.5%) focused on both primary education and secondary education. Based on the outcomes, it can be inferred that equal emphasis is placed on both primary education and secondary education which, in turn, highlights the importance of improving students' computational thinking and programming skills from a young age. Finally, based on the annual number of published documents presented in Figure 4, it can be seen that most documents were published in 2021 (n = 13, 17%) and 2020 (n = 12, 15%).

Table 2. Outlets with the highest number of published documents.

Outlet Name	Number of Documents
Education and Information Technologies	5
Journal of Educational Computing Research	4
IEEE Global Engineering Education Conference (EDUCON)	3
British Journal of Educational Technology	2
ACM Transactions on Computing Education	2
Journal of Computers in Education	2
APSCE International Conference on Computational Thinking and STEM Education (CTE-STEM)	2
European Conference on Games Based Learning (ECGBL)	2
Computers in Human Behavior	2
IEEE Transactions on Learning Technologies	2
International Conference on Advanced Learning Technologies (ICALT)	2
International Conference on Artificial Intelligence in Education (AIED)	2
International Conference of the Immersive Learning Research Network (iLRN)	2
ACM Special Interest Group on Computer Science Education (SIGCSE) Conference	2

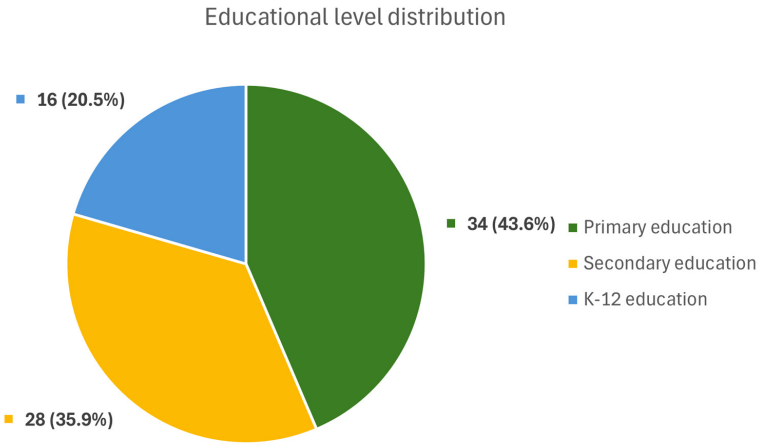


Figure 3. Educational level distribution.

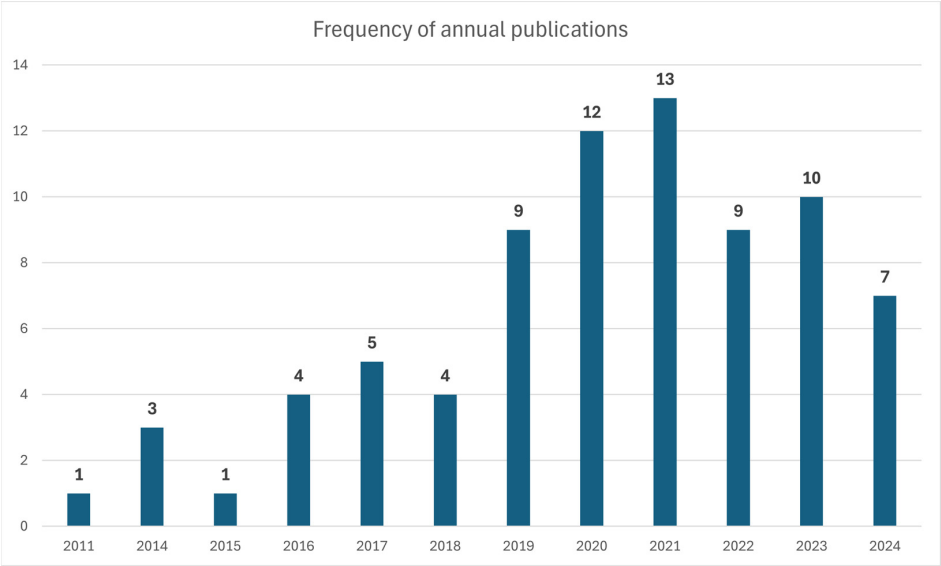


Figure 4. Frequency of annual publications.

4.2. Theoretical and Review Studies Analysis

This subsection summarizes the nine (11.5%) Theoretical and Review studies [42–50] contained in the collection analyzed. The specific documents contribute knowledge to the

field and are related to the topic but have not presented or applied a serious game or digital game in educational settings. These studies highlight the effectiveness of serious games in enhancing computational thinking across various contexts and present some of the existing challenges.

Several studies have explored the use of serious games in computer science courses in K-12 education to enhance students' programming skills. For example, aiming to explore how the integration of serious games into computer science education can influence teaching and learning, Bajramović et al. [42] compared serious games with traditional teaching methods focusing on secondary education. Based on their outcomes, students who learnt through serious games achieved higher levels of self-motivation, self-resourcefulness, and self-management. Additionally, learning through game-based learning activities arose as an effective approach to teaching computational thinking. Lindberg et al. [50] carried out a review study focusing on the integration of games into programming courses in the K-12 curriculum. The outcomes highlight the use of digital games to teach introductory programming concepts, algorithms, and computational thinking through block-based programming. The need to consider the age group of students, their programming, and their interests when integrating digital games in the classroom was highlighted and various programming games were analyzed and categorized based on their complexity. Additionally, the study pointed out that digital games can support learning theories, such as constructivism, problem-based learning, etc. and commented upon the need to better support social learning within digital games.

Moreover, in their study, Giannakoulas and Xinogalos [47] examined 22 educational games that aimed to cultivate primary school students' computational thinking through teaching programming concepts. Additionally, in another two studies, Giannakoulas and Xinogalos [43,49] focused on further examining the use of educational games to teach programming concepts to primary school students. Their outcomes highlighted that the digital games promoted students' algorithmic thinking skills, decomposition, pattern recognition, and modularity. Based on their outcomes, most studies offer a limited variety of activities, which mostly were puzzle-based. Engaging scenarios and environments, puzzles, and scoring systems were mostly applied within the digital games. Additionally, the vast number of games examined, which were mostly web-based or mobile-based single-player games, used block-based coding activities. A lack of collaborative elements and of meaningful learning analytics within the games was noticed. However, the majority of the studies examined reported that students presented positive learning outcomes and expressed positive attitudes toward programming. Hence, the use of educational games arose as a meaningful motivating factor for engaging students in computational thinking activities while learning about basic programming concepts without requiring any prior knowledge.

Furthermore, studies have also put emphasis on the use of serious games to develop students' computational thinking and problem-solving skills. In a literature review study, Varghese and Renumol [44] focused on exploring the use of video games to develop students' computational thinking in K-12 education. Their results revealed that digital games can effectively be used to foster students' computational thinking and problem-solving skills. Among the various coding activities and environments, block-based games were the most familiar and user-friendly for young learners. The study also highlighted the need for more empirical evidence regarding the influence of video games on assessing students' computational thinking. Wang et al. [45] explored how game-based teaching can be best designed and implemented in terms of game activities and instructional design when focusing on improving students' computational thinking, through a systematic review. The study puts emphasis on theoretical foundations, teaching strategies, and

learning tools. Additionally, the results of the study highlighted that this approach can positively influence students' abilities to solve problems, recognize patterns, and debug. It was highlighted that students' engagement can be increased through the use of challenges, avatars, and feedback and that there is a variability in the effectiveness of this approach in terms of knowledge acquisition. However, the outcomes revealed that there is a positive impact on students' computational thinking, skills, and understanding when learning through serious games and game-based learning approaches. Rulesets, rewards, and scores were identified as the most frequently used gamification elements.

Similarly, Zaibon and Yunus [46] focused on game-based learning, problem-solving, and computational thinking. Their outcomes revealed that students who were engaged in game-based learning computational thinking activities showcased a significant improvement in their scores and problem-solving skills compared to those who learnt through traditional methods. Hence, gameful approaches emerged as an effective means to improve students' problem-solving skills. Dutra et al. [48] focused on identifying key aspects of promoting the computational thinking of children with intellectual disabilities through the development and integration of accessible educational games. Their study proposed a set of guidelines to aid in the development of accessible games and educational material. The study highlighted the need to define clear rules, offer challenges, automate repetitions, provide examples and feedback, utilize level-based learning, and to allow students to freely explore and experiment. Additionally, the study commented upon the need for digital games to be customizable and configurable based on students' needs and preferences, enable tracking and monitoring of students' performance, provide simple interfaces, have clear language, and involve real-life scenarios and contexts.

4.3. Proposal and Showcase Studies Analysis

This subsection summarized the outcomes of the 11 (14.1%) Proposal and Showcase studies [51–61]. Studies that were categorized as Proposal and Showcase studies presented or proposed the adoption and integration of digital games or serious games into educational settings but did not apply or test them with students. Additionally, studies that carried out preliminary user testing without student participants are also included in this category. The studies of this category explore the versatility and effectiveness of serious games and digital games in various educational contexts.

Studies have designed and developed serious games targeted at K-12 education students' programming learning. For instance, Seralidou et al. [51] designed an augmented reality game focusing on teaching and learning programming structures. Additionally, the game aimed to familiarize students with programming concepts and principles. The game was evaluated by specialists who characterized it as interesting, stable, and easy to use. In their study, Giannakoulas et al. [53] presented an educational platform, which aimed at enhancing programming teaching in primary education. The platform included three modules: a management system for teachers, a web-based game for classroom use, and a mobile application. Additionally, the platform integrates learning analytics, supports distance learning, and focuses on data privacy and security. Humble et al. [54] developed and evaluated a digital game focusing on teaching basic programming techniques and principles. The preliminary user tests revealed the potential of the game to improve logical and computational thinking as well as programming knowledge. The need to enable the repetition of tasks and the gradual increase in complexity to enhance students' flow was highlighted.

Other studies focused on presenting different activities, frameworks, and toolkits to further enhance game-based learning initiatives in computer science courses. Aiming to support the teaching of programming fundamentals, Ventura et al. [60] presented a

puzzle-based digital game. The game focuses on introducing programming concepts to students and contains various levels of increasing difficulty. The study highlighted that the integration of digital games into educational activities can enhance students' engagement and persistence in learning programming. Focusing on data that derived from game interactions, Min et al. [58] presented a Long Short-term Memory Network-based stealth assessment framework to evaluate students' competencies. The study highlighted the significance of game-related data and their use to offer meaningful feedback and indications of students' learning. Park et al. [56] focused on how adaptive game levels can be generated based on students' game-playing skills and computer science learning objectives. They put emphasis on developing diverse game levels and personalized to each individual's skills challenges using answer set programming and procedural content generation (PCG) frameworks. The study stated that this approach could result in the creation of adaptive and engaging game-based learning experiences in the context of K-12 computer science education. Taylor et al. [57] presented a block-based coding toolkit that can be integrated into existing game engines to better support game-based learning activities. Their study focused on developing students' computational thinking skills and went over the specifications and capabilities of the proposed tool. Their pilot integration of the tool into a digital game highlighted the potential of this approach to enriching problem-based learning and programming learning.

Furthermore, studies have emphasized the role of serious games in affecting students' computational thinking and problem-solving skills. In their study, Hodhod et al. [61] presented an augmented reality game focusing on developing young students' problem-solving skills. The study highlighted the need to provide students with interactive learning experiences and enable them to engage with the educational platform and material. It is worth noting that students could incorporate their own toys within the augmented reality environment. Yan-Ming and Ju-Ling [52] presented a digital game that focused on improving students' computational thinking. The study highlighted the significance of examining students' perspectives and level of satisfaction and proposed a research design approach based on their developed game. The authors quoted the potential of digital games to improve students' satisfaction, increase their motivation and curiosity, and enhance computational thinking. Finally, the study highlighted the need to focus on developing students' computational thinking over information memorization. Aslina et al. [55] presented a digital game that aimed to improve primary school students' computational thinking. The study focused on presenting the user-centered design process followed to develop the game. Additionally, some preliminary tests were carried out to explore the usability and enjoyment that the game could offer before being further improved and integrated into classrooms. Schmidt and Beck [59] examined how digital game-based learning environments can influence the social skills and computational thinking of young students with autism spectrum disorder. Their digital game focused on the exploration of introductory programming problems and utilized virtual and programmable robots. The study highlighted the need to integrate social competency instruction within a computational thinking-focused curriculum and commented upon the significance of design choices.

4.4. Experimental and Case Studies Analysis

This subsection presents the analysis of the 58 (74.3%) Experimental and Case studies [62–119]. Specifically, it includes data on participants, sample, course details, course type, digital game type, platform and device, closed or open-source, existing or newly developed, game elements, development methodology, experiment type, research methods, evaluation tools, and data analysis methods.

To better understand the results, the variations in participant groups were explored. As can be seen in Figure 5, most of the documents (n = 52, 89.7%) focused on students' experiences and viewpoints. Some studies focused on teachers (n = 2, 3.4%) while others put emphasis on both students and teachers (n = 4, 6.9%). The emphasis on examining the role of serious games in students' learning and the importance of understanding their perspectives are highlighted. However, it is also significant to focus on teachers' viewpoints, skills, and abilities to effectively adopt serious games in their classrooms. Hence, it can be inferred that currently, studies focus on students' perspectives and learning outcomes, and to a lesser extent, on teachers' viewpoints and abilities to effectively integrate serious games in their classrooms. Of the 58 studies, the vast majority used random sampling (n = 54, 93.1%), which provides general results and reduces bias, as every participant has an equal chance to be selected for the study while only a few studies used non-random sampling methods (n = 4, 6.9%).

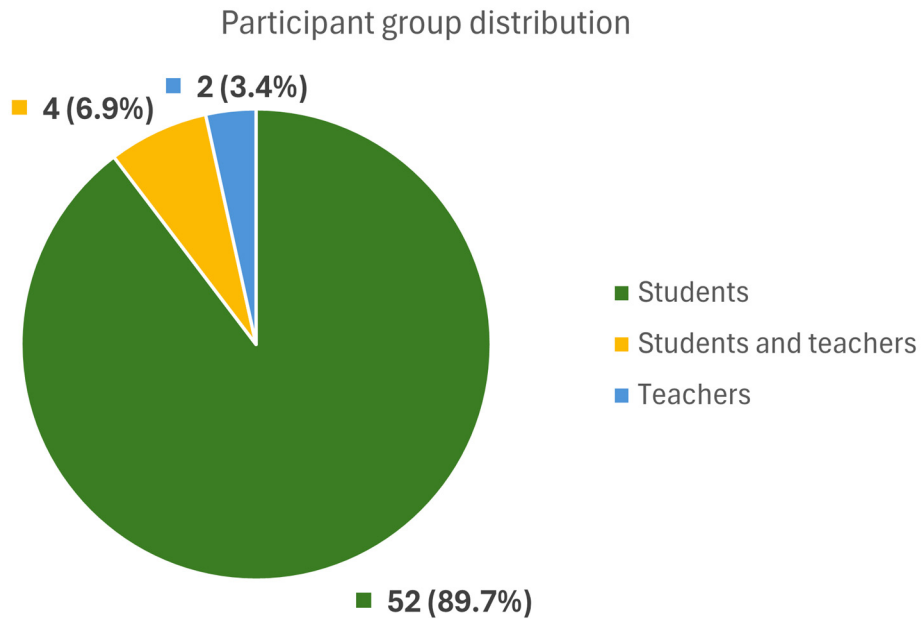


Figure 5. Participant group distribution.

Given the main field in which computational thinking and programming are taught, all studies focused on computer science courses. However, most documents did not specify any certain course details (n = 50, 86.2%). Of the few studies that did mention some specifications, the most commonly used programming language was Python. The educational environment in which the intervention is being applied and the course type can influence the educational outcomes. Hence, the course type and educational environments were also examined. The related outcomes are presented in Figure 6. Most studies focused on face-to-face courses (n = 49, 84.5%) while some adopted serious games in online courses (n = 6, 10.3%). Few studies also integrated serious games within blended learning environments (n = 3, 5.2%). These outcomes highlight the potential of serious games to be adopted and integrated into various educational environments and support teaching and learning activities. Simultaneously, these results reveal the emphasis on supporting face-to-face education and the ability to more easily carry out controlled studies in such environments. As such, it can be inferred that serious games can also enrich traditional methods of teaching.

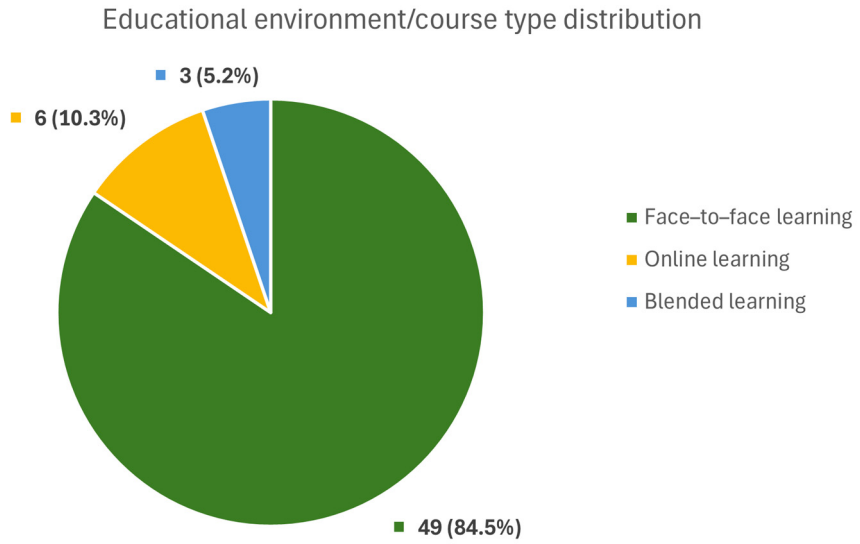


Figure 6. Educational environment/course type distribution.

Furthermore, given the scope of this study, emphasis was put on the analysis of the serious games adopted by the related studies. The games were separated into 2D games, 2.5D games, and 3D games. Particularly, 2D games refer to two-dimensional games that are characterized by the restriction of movement to height and width, 2.5D games are a blend of 2D and 3D games in which mechanics are intertwined, and 3D games are three-dimensional games that enable movement across depth, height, and width. Based on the outcomes presented in Figure 7, most studies integrated 2D games (n = 32, 55.2%), followed by those that integrated 3D games (n = 19, 32.8%). Four studies (6.9%) used 2.5D games while the specifications of the games that three studies (5.1%) used were not clearly specified within the text or were not clearly depicted in the figures used. Additionally, most of the games used were targeted at computer devices (n = 45, 77.6%) while only four studies (6.9%) utilized games targeted at mobile devices. A total of nine studies (15.5%) integrated games that could be used on both computer and mobile devices. The related outcomes are presented in Figure 8. Based on these outcomes, it can be inferred that most studies focused on developing or integrating games meant for computers which students are already familiar with and mostly practice their programming skills on. Additionally, most studies adopting 2D games can be attributed to the target group of young students as it is easier for students to comprehend them and interact with them. These outcomes also highlight the preference for the simplicity and accessibility of 2D games when teaching young students about complex concepts and promoting their computational thinking.

Various kinds of games were examined in the specific studies. The most popular games based on the number of studies that have used them are: Minecraft (n = 8) [59,72,76,79,81,84,100,116], AutoThinking (n = 4) [74,82,83,93], ENGAGE (n = 4) [56,58,95,96], CodeCombat (n = 3) [64,85,103], Escape with Python (n = 3) [54,70,75], BOTS (n = 2) [109,112], CodeMonkey (n = 2) [90,91], and sCool (n = 2) [42,97]. A total of 37 additional games were identified, each of which was used in a single study. As there were several differences in the design and nature of these games as well as in the number of studies and the environments in which the experiments took place, it is not feasible to attribute any positive or negative learning outcome to a specific game element or mechanics. This fact highlights the need for common evaluation metrics and methods to be developed and for guidelines and standards on how to create and introduce such games in educational settings to be developed.

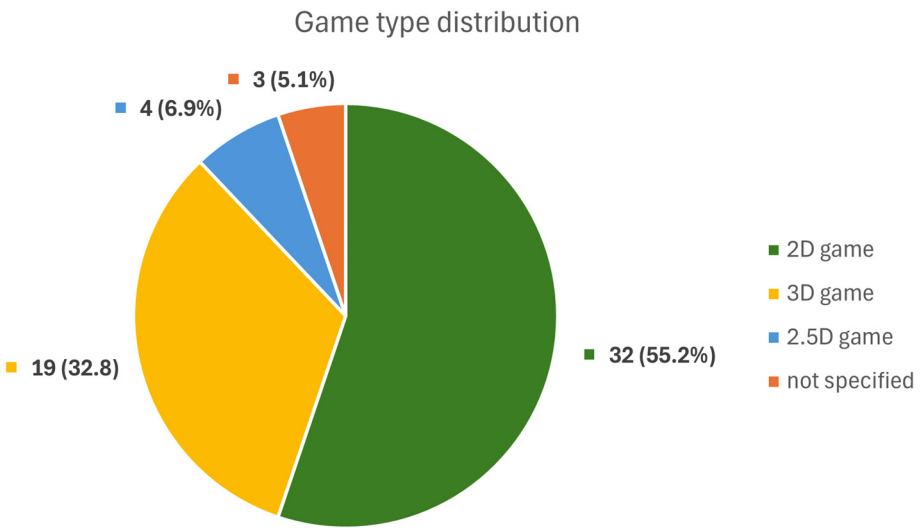


Figure 7. Game type distribution.

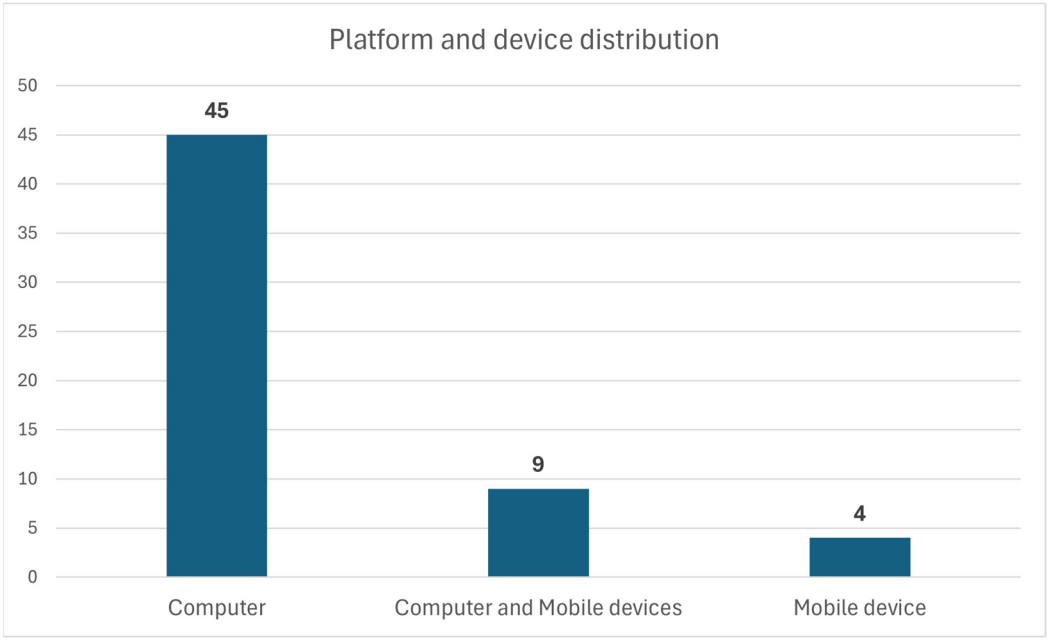


Figure 8. Platform and device distribution.

Furthermore, the significant majority of studies did not mention a specific operating system that their game was played on. However, of the few studies that did specify the operating system, Windows for computer devices and Android for mobile devices were mostly used. Most studies (n = 45, 77,6%) also did not clearly specify whether the game they used or developed was open-source or closed-source. Of the few studies that provided details, eight used closed-source games (13.8%) and five used open-source games (8.6%). Despite the limited number of studies that reported this information, the ability to adopt both closed-source and open-source games further highlights the variety and applicability of serious games. Based on the outcomes, there was a balance between using existing games (n = 31, 53.4%) and developing new ones (n = 27, 46.6%). These results highlight the fact that although existing games might have not been strictly developed for educational purposes, they can still be used to support students' learning. Finally, Figure 9 presents the main game aspects identified within the documents. The games used mostly included block-based coding activities (n = 36, 62.0%), had various levels with changing difficulties (n = 19,

32.8%), and focused on activities that cultivated students' basic programming knowledge and principles (n = 14, 24.1%). It should be noted that in these activities, students could examine and interact with existing code but also write their own code. Additionally, the games integrated mazes (n = 9, 15.5%), puzzles (n = 3, 5.2%), quizzes (n = 3, 5.2%), and platformers (n = 2, 3.4%) which highlight the vast number of interactive activities and tasks that can be used within serious games and digital games. In the "Others" category (n = 5, 8.6%), cases such as pattern recognition, board games, and interactive debugging activities were included. Finally, the development approaches followed to create the games were examined. However, the significant majority of studies did not specify a particular approach. Of the studies that clearly specified the approach they followed to develop their game and integrate it into educational settings, the Analyze, Design, Develop, Implement, and Evaluate (ADDIE) design model was mostly used.

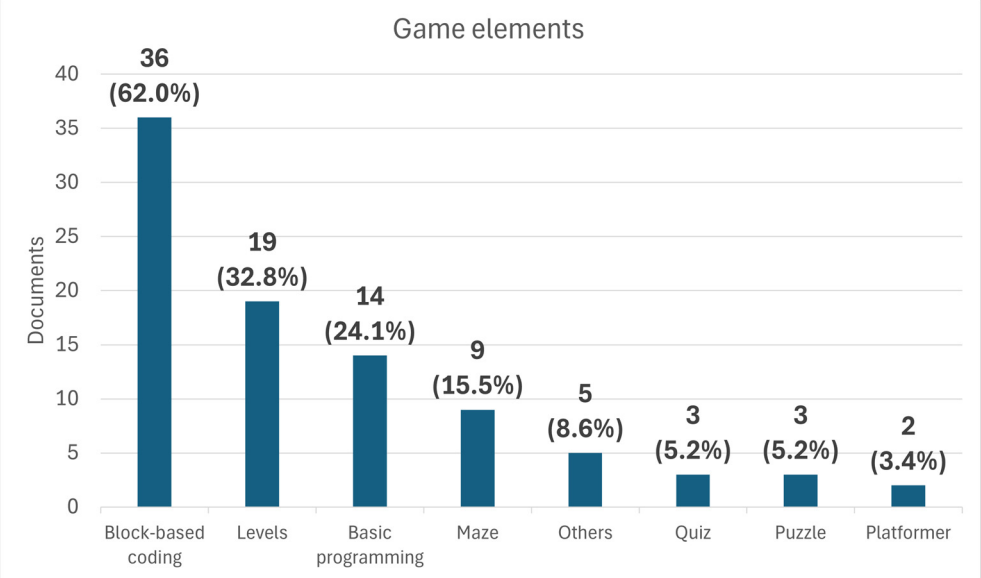


Figure 9. Distribution of game elements.

The research approaches and experiments carried out by the relevant studies were also examined. Given the categorization of the documents, the studies that were included in the Experimental and Case studies category involved studies that conducted experimental interventions. Most studies examined students' viewpoints, experiences, learning outcomes, and/or performance both prior to and after their intervention (n = 33, 56.9%), followed closely by studies that examined the related aspects only after the intervention (n = 25, 43.1%).

Additionally, most studies followed a quantitative research approach (n = 41, 70.7%) while some studies adopted a mixed methods approach (n = 15, 25.9%). Only two studies followed a qualitative research approach (n = 2, 3.4%). These outcomes were further examined focusing on the evaluation tools used. The related results are presented in Figure 10. It should be noted that some studies adopted a combination of the evaluation tools identified; thus, the total number sums up to more than 58 which is the total number of documents included in this analysis. Particularly, questionnaires and surveys were the most commonly used evaluation tools (n = 48, 82.8%), followed by tests (n = 21, 36.2%). Studies also integrated interviews (n = 11, 18.9%), observations (n = 6, 10.3%), and focus groups (n = 2, 3.4%) to better understand the influence of serious games on students and their perspectives and experiences.

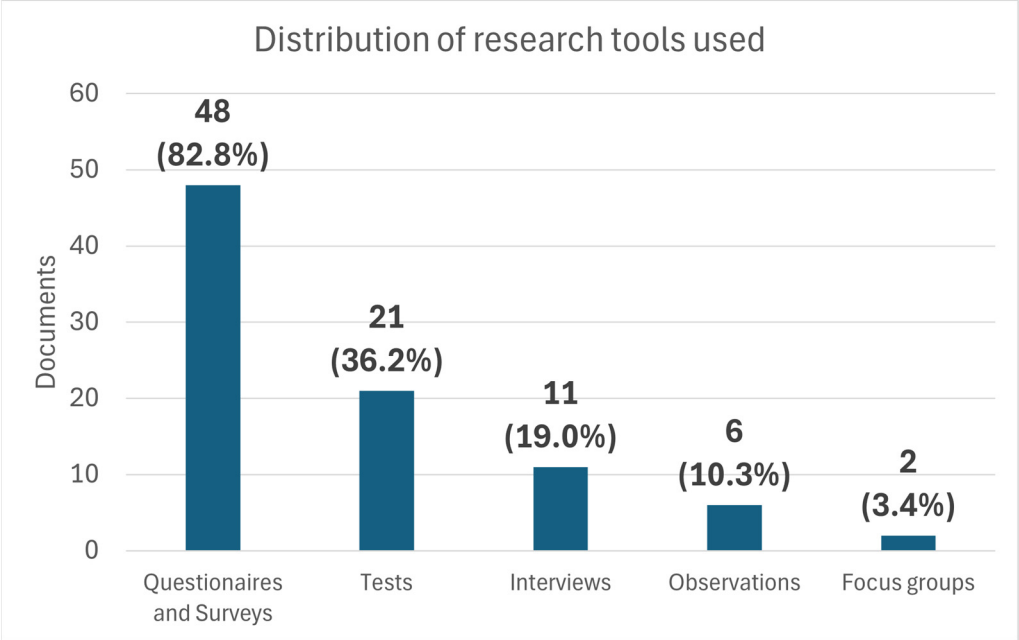


Figure 10. Distribution of research tools used.

Furthermore, most of the evaluation tools used within the studies were ad-hoc (n = 38, 65.5%). However, a total of 19 studies (32.8%) used existing evaluation tools and 1 study (1.7%) used both ad-hoc and existing evaluation tools. The existing evaluation tools were further examined and identified. The wide variety of evaluation tools used highlights the multidimensional nature of digital games and their impact on users. Specifically, the Computational Thinking Test [120] was the most commonly used tool, followed by the Technology Acceptance Model (TAM) [121]. Overall, the evaluation tools used were as follows:

- Computational Thinking Test [120].
- Technology Acceptance Model (TAM) [121].
- CS Cognitive Load Component Survey (CS CLCS) [122].
- Children IMI Interest/Enjoyment Scale [123].
- Computational Learning Test (CLT) [124].
- Thai Game Experience Questionnaire (THGEQ) [125].
- Game Experience Questionnaire (GEQ) [126].
- Computational Thinking Test for Lower Primary (CTtLP) [127].
- Elementary Student Coding Attitudes Survey (ESCAS) [128].
- Beginners Computational Thinking test [129].
- Gamefulquest [130].
- the Model for the Evaluation of Educational Games + (MEEGA+) [131].
- New General Self-Efficacy (NGSE) [132].
- Computer Science Attitudes (CSA) [133].
- Value-Expectancy STEM Assessment Scale (VESAS) [134].
- System usability scale (SUS) [135].
- EGameFlow [136].
- New Computer Game Attitude Scale (NCGAS) [137].

4.5. Main Benefits and Challenges of Using Serious Games in Education

Furthermore, emphasis was placed on identifying the main benefits and challenges associated with the adoption and use of serious games in education. To provide a better

representation of the related outcomes within the literature, all documents from all three categories were examined. Table 3 presents the key benefits that emerged while Table 4 depicts the main challenges and disadvantages identified (RQ2). The related outcomes are further analyzed in the Discussion section.

Table 3. Main benefits of using serious games in education.

Benefits	Frequency	Percentage	References
Increases learning performance	29	50.0%	[63–65,67–69,72,74,76,77,81–83,86,87,89,93,94,99–101,104,105,108–110,113,114,118]
Improves learning enjoyment	22	37.9%	[62,63,69–73,77–79,81,82,85,86,88,89,93,97,108,112,114,115]
Enhances learning motivation	18	31.0%	[63,64,70–73,77,80–82,89,93,94,97,101,108,109,114]
Promotes students' active involvement	12	20.7%	[64,71–73,81,82,86,89,93,108,114,118]
Positively viewed by students	11	19.0%	[62,64,66,81,93,97,104,106,107,115,117]
Ease of use	10	17.2%	[64,66,73,78,81,85,98,106,108,117]
Provides real-time feedback and support	5	8.6%	[78,82,87,95,96]
Promotes collaborative learning	5	8.6%	[67,89,108,115,118]
Improves confidence	4	6.9%	[86,93,106,108]
Reduces cognitive strain	2	3.4%	[64,109]

Table 4. Main challenges and disadvantages of using serious games in education.

Challenges and Disadvantages	Frequency	Percentage	References
Increased cognitive strain for some students	5	8.6%	[70,72,75,77,111]
Students required assistance to play the game and complete the learning tasks	3	5.2%	[77,101,112]
Students expressed negative feelings (e.g., dislike, boredom, lack of freedom etc.)	3	5.2%	[70,75,77]
Technical difficulties	3	5.2%	[70,77,112]
Unclear learning goals and tasks	2	3.4%	[70,111]
The game made programming tedious	2	3.4%	[70,115]

5. Discussion

Gameful approaches can positively influence students' learning performance and experiences [138–141]. As serious games present great potential to support the educational process and enhance students' programming skills and computational thinking, they are being more widely used in educational settings [13,14]. When students learn through serious games, they are engaged in experiential and hands-on learning activities [45]. Serious games support collaborative and social learning [19] as well as feedback and personalization through learning analytics [53]. Additionally, while being engaged in such game activities, students can get familiar with basic programming concepts without any prior knowledge being required [43,142]. When appropriately designed, serious games can contribute toward making education more accessible and inclusive while supporting both students and teachers [48,143].

Moreover, the outcomes of the analysis are in line with and further expand upon those of the literature [44]. Based on the outcomes, it was revealed that the use of serious games and digital games in educational settings had a positive impact on the educational process as it was also highlighted in previous studies [19,21–23]. To better comprehend the benefits yielded through the integration of serious games in the context of computational thinking and programming learning, the content analysis also put emphasis on identifying and categorizing the main benefits reported in the literature. The frequency of the main benefits and the related studies that have referred to each individual benefit are presented in Table 3 and Figure 11. Specifically, students who learnt through the use of serious games reported increased learning performance (n = 29, 50%), showcased improved learning enjoyment (n = 22, 37.9%), and presented enhanced learning motivation (n = 18, 31%). Additionally, serious games promoted students' active participation (n = 12, 20.7%) and were positively

viewed by students (n = 11, 19%). Additionally, in some cases, the usability of the digital games, their ease of use, and their being familiar to students emerged as another benefit (n = 10, 17.2%). Other benefits that were identified, but to a lesser extent, were the ability of serious games to provide feedback and support in real time (n = 5, 8.6%), to support collaborative learning (n = 5, 8.6%), to enhance students' confidence (n = 4, 6.9%), and to reduce their cognitive strain (n = 2, 3.4%). These outcomes further highlight the value that serious games can bring about in the educational process and their ability to increase students' computational thinking and programming skills.

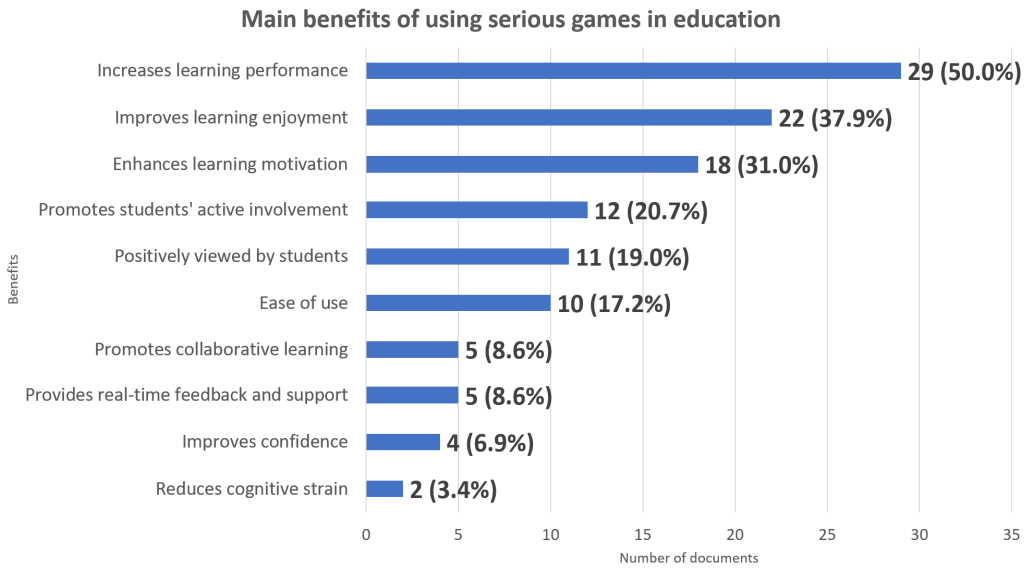


Figure 11. Main benefits of using serious games in education.

Nonetheless, the study also identified the main disadvantages and challenges associated with the integration of serious games. The related outcomes are presented in detail in Table 4 and Figure 12. In particular, few studies reported that the integration of complex serious games increased students' cognitive strain (n = 5, 8.6%) and assistance was required for them to play the game and complete the learning tasks (n = 3, 5.2%). Additionally, some studies reported that students expressed negative feelings, such as boredom, lack of freedom within the game, etc. (n = 3, 5.2%) as well as technical difficulties (n = 3, 5.2%). In other cases, the learning goals and tasks were deemed unclear (n = 2, 3.4%) and the game activities related to programming were regarded as tedious (n = 2, 3.4%). It is worth highlighting that the challenges and disadvantages identified are highly connected to the design of serious games. Based on these outcomes, it can be inferred that emphasis should be placed throughout the process of designing and developing serious games, students' preferences, skills, and knowledge should be considered, and cooperative development approaches that involve education stakeholders should be followed. Hence, there is a clear need to further examine the design aspects that render serious games successful within educational settings.

Based on the outcomes, serious games emerged as a valuable educational means that can be used in face-to-face, online, and blended learning to improve students' programming skills and computational thinking. Serious games can also enhance students' self-regulated learning as well as promote social learning within groups. Overall, students were positive about the integration and use of serious games in educational settings and valued the elements of in-game feedback and support highly. Additionally, students were fond of more challenging tasks and activities as they found them more intriguing. In the studies that did explore the influence of students' gender, no significant differences were observed between

male and female students. However, female students showcased an increased interest in games that promote creativity. A strong relationship was observed between students' prior involvement in playing games and the time spent playing with their problem-solving skills, critical thinking, and performance. Students' computational thinking was also correlated with their academic performance. Students who reported higher levels of computational thinking performed better than those with lower computational thinking skills. Promoting intrinsic motivation through games proved more effective for students who were actively engaged in the learning process while fostering extrinsic motivation had a greater impact on students who were less involved. Despite the benefits that the integration of serious games in education can yield, emphasis should be put on their design and development. Additionally, parents' support and the approaches that teachers use also play a vital role in the adoption of serious games. Hence, there is a need to understand K-12 teachers' digital competencies and programming skills [144], their perspectives regarding the use of serious games, and their ability to effectively integrate them into their classrooms.

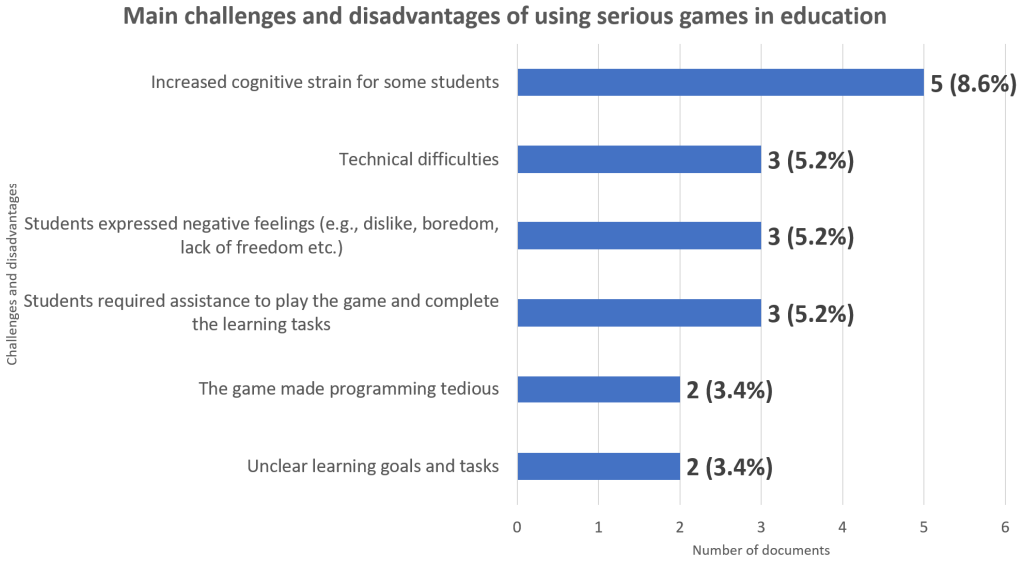


Figure 12. Main challenges and disadvantages of using serious games in education.

Given the outcomes of this study, it is highlighted that serious games constitute an effective and promising educational means. However, it is important for educators and policymakers to carefully plan and design appropriate initiatives, policies, practices, and frameworks to adopt and integrate serious games in classrooms. It is also essential to invest in the technological infrastructure of educational institutes and schools, in the development of appropriate serious games, and in the creation of game-based curricula. Initiatives should also be taken to ensure that students and schools have access to high-quality serious games that meet the curriculum standards. Policymakers should also focus on establishing benchmarks, guidelines, and assessment methods to evaluate the efficiency of serious games and their impact on students' learning. It is also vital to ensure the enhancement of teachers' skills and knowledge through suitable professional development and training programs so that teachers are capable of effectively integrating serious games into their teaching practices. Teachers should ensure that the games they introduce in their classrooms support the learning goals and meet the curriculum specifications and standards. The nature of the game, its activities, and its complexity should be carefully selected based on the characteristics (e.g., age group, skills, etc.) of the students and the subject matter to ensure that serious games that offer meaningful content and challenge students to reason and think critically are used. It is important to note that serious games can support blended learning

environments and that they can be used to enrich traditional instruction methods and approaches to create more student-centered learning environments that promote students' engagement and motivation. When creating serious games that aim at being integrated into the school curriculum, education stakeholders should be involved throughout the design and development process. For serious games to be more widely and efficiently integrated into school curricula and support students' learning, collaboration among policymakers, education stakeholders, and developers should be fostered and consistent support from all education levels should be provided.

6. Conclusions

Serious games and digital games, in general, are increasingly being used in educational settings due to the benefits they can yield as well as the familiarity of students with them. Programming skills, problem-solving, and computational thinking have become important aspects of modern education. This study explored the role and impact of serious games and digital games on K-12 students' computational thinking and programming skills through a systematic literature review. Although this study explored the related documents from various dimensions using mixed methods, there are some limitations that should be highlighted. Specifically, the study examined documents that were written in English only and which were indexed in one of the three databases used. Hence, future studies should further examine this topic by exploring documents indexed in other databases and written in different languages to better assess the impact of digital games. Additionally, given the nature of this study, the focus was on computer science-related courses as presented by the results. Hence, future studies should also examine the influence of serious games on other courses and students' skills. Finally, this study focused solely on primary education, secondary education, and K-12 education.

Based on the outcomes and focusing on addressing RQ3, the study highlighted the positive influence that serious games and digital games have on students' programming skills and computational thinking. As a result, they are positively viewed by education stakeholders. Additionally, it revealed the increased interest in the topic with more relevant studies being published by authors from various countries while maintaining a balance between the studies that focus on primary education and secondary education. Serious games emerged as effective educational means that can provide meaningful learning experiences as they can increase students' learning performance, enjoyment, and motivation, promote their active involvement, and improve their confidence. Serious games also promote participatory learning, support social learning, and help students develop their social skills, such as communication and collaboration. They also offer adaptive learning experiences, provide real-time feedback and support, enable the effective management of cognitive load, and promote personalized learning and self-regulated learning. Finally, the challenges identified are closely related to the design elements, decisions, and approaches which indicates that they can be mitigated and overcome as the issues are not related to the approach or the gameful intervention in itself. Based on the analysis of the literature and the findings of this study, the following key design aspects and principles were identified (RQ4):

- Follow collaborative design and development approaches and strategies and involve education stakeholders.
- Provide a variety of dynamic and interactive content, tasks, and mechanics.
- Offer real-time and personalized feedback and assessment.
- Support scaffolding, multimedia, and accessibility features and materials.
- Contain reward mechanics and levels of increasing difficulty.

- Promote social interaction and collaboration with other peers and non-player characters (NPCs).
- Focus on learning objectives but maintain a balance between enjoyment and learning.
- Emphasize user experience by improving usability and having user-friendly interfaces.
- Contain data collection mechanics to assess students' performance and the effectiveness of the game.
- Offer adaptive and personalized experiences.
- Consider learners' characteristics, preferences, and existing knowledge and skills.

Based on the outcomes of the studies examined, there is a clear need for more experimental and case studies to be conducted that explore the influence of serious games for prolonged time periods and examine their impact on cross-cultural settings. This is particularly true as the duration of the intervention in the studies was quite limited and the experiments and interventions took place in specific settings. There is also a lack of empirical data on the impact of serious games on cross-cultural settings and on long-term interventions. Future studies should also emphasize the use of serious games in online learning and blended learning settings as well. There is also a need to examine parents' and teachers' perspectives as well as assess the competencies of teachers to effectively integrate serious games in their classrooms. As the studies used either ad-hoc or diverse evaluation tools, there is a clear need for more holistic assessment tools and approaches to be developed. Although this study identified some key design elements, given the importance of the design of serious games, future studies should focus on identifying the key aspects associated with the successful development and integration of serious games, how they affect learning outcomes, and provide guidelines and recommendations. As there are various types of games that can be adopted in educational settings, the game type and the devices that students use should also be explored. As technological advancements progress, future studies should examine the use of artificial intelligence, augmented reality and virtual reality technologies, as well as learning analytics within serious games and digital games.

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References

1. Ananiadou, K.; Claro, M. 21st Century Skills and Competences for New Millennium Learners in OECD Countries. *OECD Educ. Work. Pap.* **2009**, *41*, 1–31. [CrossRef]
2. Padhi, P.K. Soft Skills: Education beyond Academics. *IOSR J. Humanit. Soc. Sci.* **2014**, *19*, 1–3. [CrossRef]
3. Geisinger, K.F. 21st Century Skills: What Are They and How Do We Assess Them? *Appl. Meas. Educ.* **2016**, *29*, 245–249. [CrossRef]
4. Thornhill-Miller, B.; Camarda, A.; Mercier, M.; Burkhardt, J.M.; Morisseau, T.; Bourgeois-Bougrine, S.; Lubart, T. Creativity, Critical Thinking, Communication, and Collaboration: Assessment, Certification, and Promotion of 21st Century Skills for the Future of Work and Education. *J. Intell.* **2023**, *11*, 54. [CrossRef]

5. Mohaghegh, D.M.; McCauley, M. Computational Thinking: The Skill Set of the 21st Century. *Int. J. Comput. Sci. Inf. Technol.* **2016**, *7*, 1524–1530.
6. Robins, A.; Rountree, J.; Rountree, N. Learning and Teaching Programming: A Review and Discussion. *Comput. Sci. Educ.* **2003**, *13*, 137–172. [CrossRef]
7. Abesadze, S.; Nozadze, D. Make 21st Century Education: The Importance of Teaching Programming in Schools. *Int. J. Learn. Teach.* **2020**, *6*, 158–163. [CrossRef]
8. McClelland, K.; Grata, L.A. Review of the Importance of Computational Thinking in K-12. In Proceedings of the eLmL 2018: The Tenth International Conference on Mobile, Hybrid, and On-Line Learning, Rome, Italy, 25–29 March 2018; pp. 2–34.
9. Angeli, C. The Effects of Scaffolded Programming Scripts on Pre-Service Teachers' Computational Thinking: Developing Algorithmic Thinking through Programming Robots. *Int. J. Child-Comput. Interact.* **2022**, *31*, 100329. [CrossRef]
10. Tsarva, K.; Moeller, K.; Román-González, M.; Golle, J.; Leifheit, L.; Butz, M.V.; Ninaus, M. A Cognitive Definition of Computational Thinking in Primary Education. *Comput. Educ.* **2022**, *179*, 104425. [CrossRef]
11. Wing, J.M. Computational Thinking. *Commun. ACM* **2006**, *49*, 33–35. [CrossRef]
12. Wei, Y.; Wang, L.; Tang, Y.; Su, J.; Lei, Y.; Peng, W. Influence of Programming Education Modalities on the Computational Thinking in Young Children: A Comprehensive Review and Meta-Analysis. *J. Comput. Assist. Learn.* **2024**, *40*, 2385–2397. [CrossRef]
13. Cheng, G.M.; Chen, C.P. Processing Analysis of Swift Playgrounds in a Children's Computational Thinking Course to Learn Programming. *Computers* **2021**, *10*, 68. [CrossRef]
14. Ds Lee, T.Y.; Mauriello, M.L.; Ahn, J.; Bederson, B.B. CTArcade: Computational Thinking with Games in School-Age Children. *Int. J. Child-Comput. Interact.* **2014**, *2*, 26–33. [CrossRef]
15. 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]
16. Clark, D.B.; Tanner-Smith, E.E.; Killingsworth, S.S. Digital games, design, and learning: A systematic review and meta-analysis. *Rev. Educ. Res.* **2016**, *86*, 79–122. [CrossRef]
17. Hsiao, H.C. A brief review of digital games and learning. In Proceedings of the 2007 First IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning (DIGITEL'07), Jhongli, Taiwan, 26–28 March 2007; pp. 124–129. [CrossRef]
18. Laamarti, F.; Eid, M.; El Saddik, A. An Overview of Serious Games. *Int. J. Comput. Games Technol.* **2014**, *2014*, 358152. [CrossRef]
19. Zhonggen, Y. A Meta-Analysis of Use of Serious Games in Education over a Decade. *Int. J. Comput. Games Technol.* **2019**, *2019*, 4797032. [CrossRef]
20. Bellotti, F.; Berta, R.; De Gloria, A. Designing Effective Serious Games: Opportunities and Challenges for Research. *Int. J. Emerg. Technol. Learn. IJET* **2010**, *5*, 22. [CrossRef]
21. Backlund, P.; Hendrix, M. Educational Games—Are They Worth the Effort? A Literature Survey of the Effectiveness of Serious Games. In Proceedings of the 2013 5th International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES), Poole, UK, 11–13 September 2013; pp. 1–8. [CrossRef]
22. Connolly, T.M.; Boyle, E.A.; MacArthur, E.; Hainey, T.; Boyle, J.M. A Systematic Literature Review of Empirical Evidence on Computer Games and Serious Games. *Comput. Educ.* **2012**, *59*, 661–686. [CrossRef]
23. Girard, C.; Ecalle, J.; Magnan, A. Serious Games as New Educational Tools: How Effective Are They? A Meta-Analysis of Recent Studies. *J. Comput. Assist. Learn.* **2013**, *29*, 207–219. [CrossRef]
24. Çiftci, S. Trends of Serious Games Research from 2007 to 2017: A Bibliometric Analysis. *J. Educ. Train. Stud.* **2018**, *6*, 18–27. [CrossRef]
25. Hallinger, P.; Wang, R.; Chatpinyakoop, C.; Nguyen, V.T.; Nguyen, U.P. A Bibliometric Review of Research on Simulations and Serious Games Used in Educating for Sustainability, 1997–2019. *J. Clean. Prod.* **2020**, *256*, 120358. [CrossRef]
26. Wang, Y.; Wang, Z.; Liu, G.; Wang, Z.; Wang, Q.; Yan, Y.; Pang, X. Application of Serious Games in Health Care: Scoping Review and Bibliometric Analysis. *Front. Public Health* **2022**, *10*, 896974. [CrossRef] [PubMed]
27. Young, M.F.; Slota, S.; Cutter, A.B.; Jalette, G.; Mullin, G.; Lai, B.; Yukhymenko, M. Our Princess Is in Another Castle: A Review of Trends in Serious Gaming for Education. *Rev. Educ. Res.* **2012**, *82*, 61–89. [CrossRef]
28. Ravyse, W.S.; Seugnet Blignaut, A.; Leendertz, V.; Woolner, A. Success Factors for Serious Games to Enhance Learning: A Systematic Review. *Virtual Real.* **2017**, *21*, 31–58. [CrossRef]
29. Cheng, M.T.; Chen, J.H.; Chu, S.J.; Chen, S.Y. The Use of Serious Games in Science Education: A Review of Selected Empirical Research from 2002 to 2013. *J. Comput. Educ.* **2015**, *2*, 353–375. [CrossRef]
30. Gorbanev, I.; Agudelo-Londoño, S.; González, R.A.; Cortes, A.; Pomares, A.; Delgadillo, V. A Systematic Review of Serious Games in Medical Education: Quality of Evidence and Pedagogical Strategy. *Med. Educ. Online* **2018**, *23*, 1438718. [CrossRef]
31. Ibarra, M.J.; Moscoso, B.B.; Aiquipa, E.G.; Madariaga, R.E.C.; Huacoto, J.L.D.; Bendezu, M.P.L. A Systematic Literature Review of Empirical Evidence on Serious Game for Mathematics Learning. In Proceedings of the 2020 XV Conferencia Latinoamericana de Tecnologías de Aprendizaje (LACLO), Virtual Event, 19–23 October 2020; pp. 1–6.

32. Miljanovic, M.A.; Bradbury, J.S. A Review of Serious Games for Programming. In *Serious Games: 4th Joint International Conference, JCSG 2018, Darmstadt, Germany, November 7–8, 2018, Proceedings 4*; Springer International Publishing: Cham, Switzerland, 2018; pp. 204–216. [CrossRef]
33. Kazimoglu, C.; Kiernan, M.; Bacon, L.; Mackinnon, L. A Serious Game for Developing Computational Thinking and Learning Introductory Computer Programming. *Procedia—Soc. Behav. Sci.* **2012**, *47*, 1991–1999. [CrossRef]
34. Toukiloglou, P.; Xinogalos, S. A Systematic Literature Review on Adaptive Supports in Serious Games for Programming. *Information* **2023**, *14*, 277. [CrossRef]
35. Abbasi, S.; Kazi, H.; Khowaja, K. A Systematic Review of Learning Object-Oriented Programming through Serious Games and Programming Approaches. In Proceedings of the 2017 4th IEEE International Conference on Engineering Technologies and Applied Sciences (ICETAS), Salmabad, Bahrain, 29 November–1 December 2017; pp. 1–6. [CrossRef]
36. Tatar, C.; Eseryel, D. A Literature Review: Fostering Computational Thinking through Game-Based Learning in K-12. In Proceedings of the 42nd Annual Convention of the Association for the Educational Communications and Technology, AECT, Indianapolis, IN, USA, 13 December 2019; pp. 288–297.
37. Al-Zubidy, A.; Carver, J.C. Identification and Prioritization of SLR Search Tool Requirements: An SLR and a Survey. *Empir. Softw. Eng.* **2018**, *24*, 139–169. [CrossRef]
38. 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. *BMJ* **2021**, *372*, n71. [CrossRef] [PubMed]
39. Sarkis-Onofre, R.; Catalá-López, F.; Aromataris, E.; Lockwood, C. How to Properly Use the PRISMA Statement. *Syst. Rev.* **2021**, *10*, 117. [CrossRef] [PubMed]
40. Mongeon, P.; Paul-Hus, A. The Journal Coverage of Web of Science and Scopus: A Comparative Analysis. *Scientometrics* **2015**, *106*, 213–228. [CrossRef]
41. Zhu, J.; Liu, W. A Tale of Two Databases: The Use of Web of Science and Scopus in Academic Papers. *Scientometrics* **2020**, *123*, 321–335. [CrossRef]
42. Bajramović, A.; Steinmaurer, A.; Gütl, C. Playing Video Games to Learn Computational Thinking? A Case Study of Game-Based Learning in Secondary CS Education. In *Towards a Hybrid, Flexible and Socially Engaged Higher Education*; Auer, M.E., Cukierman, U.R., Vendrell Vidal, E., Tovar Caro, E., Eds.; Lecture Notes in Networks and Systems; Springer: Cham, Switzerland, 2024; pp. 474–482. [CrossRef]
43. Giannakoulas, A.; Xinogalos, S. Studying the Effects of Educational Games on Cultivating Computational Thinking Skills to Primary School Students: A Systematic Literature Review. *J. Comput. Educ.* **2023**, *11*, 1283–1325. [CrossRef]
44. Varghese, V.V.; Renumol, V.G. Video Games for Assessing Computational Thinking: A Systematic Literature Review. *J. Comput. Educ.* **2024**, *11*, 921–966. [CrossRef]
45. Wang, X.; Cheng, M.; Li, X. Teaching and Learning Computational Thinking through Game-Based Learning: A Systematic Review. *J. Educ. Comput. Res.* **2023**, *61*, 1505–1536. [CrossRef]
46. Zaibon, S.B.; Yunus, E. The Effectiveness of Game-Based Learning Application Integrated with Computational Thinking Concept for Improving Student's Problem-Solving Skills. In *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*; Springer: Cham, Switzerland, 2022; pp. 429–442. [CrossRef]
47. Giannakoulas, A.; Xinogalos, S. A Review of Educational Games for Teaching Programming to Primary School Students. In *Research Anthology on Developments in Gamification and Game-Based Learning*; IGI Global: Hershey, PA, USA, 2022; pp. 55–83. [CrossRef]
48. Dutra, T.C.; Felipe, D.; Gasparini, I.; Maschio, E. Educational Digital Games and Computational Thinking for Students with Intellectual Disabilities—Guidelines for Accessibility. In Proceedings of the 2021 International Conference on Advanced Learning Technologies (ICALT), Tartu, Estonia, 12–15 July 2021; pp. 101–104. [CrossRef]
49. Giannakoulas, A.; Xinogalos, S. Current Trends in Online Games for Teaching Programming Concepts to Primary School Students. In *Communications in Computer and Information Science*; Springer: Cham, Switzerland, 2019; pp. 62–78. [CrossRef]
50. Lindberg, R.S.N.; Laine, T.H.; Haaranen, L. Gamifying Programming Education in K-12: A Review of Programming Curricula in Seven Countries and Programming Games. *Br. J. Educ. Technol.* **2019**, *50*, 1979–1995. [CrossRef]
51. Seralidou, E.; Karousou, M.; Douligeris, C. An AR Application for Mobile Devices to Support the Educational Process in Greek Secondary Education. In Proceedings of the 2024 IEEE Global Engineering Education Conference (EDUCON), Kos Island, Greece, 8–11 April 2024; pp. 1–8. [CrossRef]
52. Yan-Ming, C.; Ju-Ling, S. Bebras in the Digital Game <Captain Bebras> for Students' Computational Thinking Abilities. In Proceedings of the CTE-STEM 2022 Conference, Chiang Mai, Thailand, 23–25 June 2022. [CrossRef]
53. Giannakoulas, A.; Terzopoulos, G.; Xinogalos, S.; Satratzemi, M. A Proposal for an Educational Game Platform for Teaching Programming to Primary School Students. In *Communications in Computer and Information Science*; Springer: Cham, Switzerland, 2021; pp. 463–475. [CrossRef]

54. Humble, N.; Mozelius, P.; Sällvin, L. You Can't Escape Learning, but Maybe You Can Get Out of the Room!—Game-Based Learning for Programming Education. In Proceedings of the 15th European Conference on Game Based Learning (ECGBL 2021), Brighton, UK, 23–24 September 2021; pp. 359–367.
55. Aslina, Y.R.; Mulyanto, A.; Niwanputri, G.S. Designing "Bebras" Serious Games Interaction for Indonesian Upper Elementary School Students. In Proceedings of the 2020 7th International Conference on Advance Informatics: Concepts, Theory and Applications (ICAICTA), Tokoname, Japan, 16–17 September 2020; pp. 1–6. [CrossRef]
56. Park, K.; Mott, B.; Min, W.; Wiebe, E.; Boyer, K.E.; Lester, J. Generating Game Levels to Develop Computer Science Competencies in Game-Based Learning Environments. In *Lecture Notes in Computer Science*; Springer: Cham, Switzerland, 2020; pp. 240–245. [CrossRef]
57. Taylor, S.; Min, W.; Mott, B.; Emerson, A.; Smith, A.; Wiebe, E.; Lester, J. Position: IntelliBlox—A Toolkit for Integrating Block-Based Programming into Game-Based Learning Environments. In Proceedings of the 2019 IEEE Blocks and Beyond Workshop (B&B), Memphis, TN, USA, 12–13 October 2019; pp. 55–58.
58. Min, W.; Frankosky, M.H.; Mott, B.W.; Wiebe, E.N.; Boyer, K.E.; Lester, J.C. Inducing Stealth Assessors from Game Interaction Data. In *Lecture Notes in Computer Science*; Springer: Cham, Switzerland, 2017; pp. 212–223. [CrossRef]
59. Schmidt, M.; Beck, D. Computational Thinking and Social Skills in Virtuoso: An Immersive, Digital Game-Based Learning Environment for Youth with Autism Spectrum Disorder. In *Communications in Computer and Information Science*; Springer: Cham, Switzerland, 2016; pp. 113–121. [CrossRef]
60. Ventura, M.; Ventura, J.; Baker, C.; Viklund, G.; Roth, R.; Broughman, J. Development of a Video Game That Teaches the Fundamentals of Computer Programming. In Proceedings of the SoutheastCon 2015, Fort Lauderdale, FL, USA, 9–12 April 2015; pp. 1–4. [CrossRef]
61. Hodhod, R.; Fleenor, H.; Nabi, S. Adaptive Augmented Reality Serious Game to Foster Problem-Solving Skills. In *Workshop Proceedings of the 10th International Conference on Intelligent Environments*; IOS Press: Amsterdam, The Netherlands, 2014; pp. 273–284. [CrossRef]
62. Arianti, A.S.; Pamungkas, G.Z.; Hambali, Y.A.; Anisyah, A.; Supriadi, O.A. Designing RPG-Based Education Game with Discovery Learning Model for Vocational High School. *J. Eng. Sci. Technol.* **2024**, *19*, 911–925.
63. Branthôme, M. Pyrates: Design and Evaluation of a Serious Game Aimed at Introducing Python Programming and Easing the Transition from Blocks. *ACM Trans. Comput. Educ.* **2024**, *24*, 1–24. [CrossRef]
64. Choi, W.C.; Choi, W.C.; Choi, I.C. Investigating the Effect of the Serious Game CodeCombat on Cognitive Load in Python Programming Education. In Proceedings of the 2024 IEEE World Engineering Education Conference (EDUNINE), Guatemala City, Guatemala, 18–21 March 2024; pp. 1–6. [CrossRef]
65. Liu, T. Assessing Implicit Computational Thinking in Game-Based Learning: A Logical Puzzle Game Study. *Br. J. Educ. Technol. J. Counc. Educ. Technol.* **2024**, *55*, 2357–2382. [CrossRef]
66. Tikva, C.; Mousiou, M.; Tambouris, E. Educational Games for Computational Thinking: Evaluation of the Scaffolded aMazeD Game. In *Lecture Notes in Computer Science: Generative Intelligence and Intelligent Tutoring Systems*; Springer: Cham, Switzerland, 2024; pp. 96–103. [CrossRef]
67. Chen, L.-X.; Su, S.-W.; Chen, Y.-Y.; Liao, C.-H.; Yuan, S.-M. A Comparison of Online and Offline Digital Gameplay Activities in Promoting Computational Thinking in K-12 Education. In Proceedings of the 2023 IEEE 5th Eurasia Conference on Biomedical Engineering, Healthcare and Sustainability, Taipei, Taiwan, 5–8 May 2023; p. 31. [CrossRef]
68. Farias, A.F.; Augusto Couto Barone, D. Computational Thinking through an Online Game to Develop Soft and Hard Skills. In Proceedings of the 2023 32nd Annual Conference of the European Association for Education in Electrical and Information Engineering (EAEEIE), Coimbra, Portugal, 14–16 June 2023; pp. 1–6. [CrossRef]
69. Jiang, X.; Harteveld, C.; Yang, Y.; Fung, A.; Huang, X.; Chen, S. "If It's Sunny, Don't Take an Umbrella": A Systematic Evaluation of Design Principles for CT Teaching Games. *Educ. Technol. Res. Dev. ETR D* **2023**, *71*, 1725–1763. [CrossRef]
70. Mozelius, P.; Humble, N. Design Factors for an Educational Game Where Girls and Boys Play Together to Learn Fundamental Programming. In *Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering*; Springer: Cham, Switzerland, 2023; pp. 134–148. [CrossRef]
71. Handayani, R.D.; Prastowo, S.B.; Jamalludin; Triyanto; Thohir, M.A. Students' Engagement in Computational Thinking Skills Using a Game-Based Learning. In Proceedings of the 2023 9th International Conference on Education and Technology (ICET), Malang, Indonesia, 19–21 September 2023; pp. 148–151. [CrossRef]
72. Qu, Z.; Wang, X.; Zhang, W. A Study on Game Teaching in Python Programming Teaching for Middle School. In *Communications in Computer and Information Science*; Springer: Cham, Switzerland, 2023; pp. 73–85. [CrossRef]
73. Zhang, S.; Wong, G.K.W.; Chan, P.C.F. Playing Coding Games to Learn Computational Thinking: What Motivates Students to Use This Tool at Home? *Educ. Inf. Technol.* **2023**, *28*, 193–216. [CrossRef] [PubMed]
74. Hooshyar, D. Effects of Technology-Enhanced Learning Approaches on Learners with Different Prior Learning Attitudes and Knowledge in Computational Thinking. *Comput. Appl. Eng. Educ.* **2022**, *30*, e22442. [CrossRef]

75. Humble, N.; Mozelius, P. Refurbishing the Educational Escape Room for Programming: Lowering the Threshold and Raising the Ceiling. In Proceedings of the 16th European Conference on Game-Based Learning (ECGBL 2022), Lisbon, Portugal, 6–7 October 2022; Academic Conferences International Limited: Reading, UK; pp. 279–286.
76. Kutay, E.; Oner, D. Coding with Minecraft: The Development of Middle School Students' Computational Thinking. *ACM Trans. Comput. Educ. TOCE* **2022**, *22*, 1–19. [CrossRef]
77. Sungkaew, K.; Lungban, P.; Lamhya, S. Game Development Software Engineering: Digital Educational Game Promoting Algorithmic Thinking. *Int. J. Electr. Comput. Eng.* **2022**, *12*, 5393–5404. [CrossRef]
78. Toukiloglou, P.; Xinogalos, S. NanoDoc: Designing an Adaptive Serious Game for Programming with Working Examples Support. In Proceedings of the European Conference on Games-Based Learning (ECGBL), Lisbon, Portugal, 6–7 October 2022; Academic Conferences International Limited: Reading, UK; pp. 628–636.
79. Vostinar, P.; Dobrota, R. Minecraft as a Tool for Teaching Online Programming. In Proceedings of the 2022 45th Jubilee International Convention on Information, Communication and Electronic Technology (MIPRO), Opatija, Croatia, 23–27 May 2022; pp. 1113–1118. [CrossRef]
80. Zhang, S.; Wong, K.W.G.; Chan, P. Integrating Game-Based Learning into Computational Thinking Class for Lower Primary Students: Lesson Design and Course Effect. In Proceedings of the Sixth APSCE International Conference on Computational Thinking and STEM Education (CTE-STEM 2022), Delft, The Netherlands, 11–13 July 2022; TU Delft Open: Delft, The Netherlands, 2022. [CrossRef]
81. Demirkiran, M.C.; Hocanin, F.T. An Investigation on Primary School Students' Dispositions Towards Programming with Game-Based Learning. *Educ. Inf. Technol.* **2021**, *26*, 3871–3892. [CrossRef]
82. Hooshyar, D.; Malva, L.; Yang, Y.; Pedaste, M.; Wang, M.; Lim, H. An Adaptive Educational Computer Game: Effects on Students' Knowledge and Learning Attitude in Computational Thinking. *Comput. Hum. Behav.* **2021**, *114*, 106575. [CrossRef]
83. Hooshyar, D.; Pedaste, M.; Yang, Y.; Malva, L.; Hwang, G.-J.; Wang, M.; Delev, D. From Gaming to Computational Thinking: An Adaptive Educational Computer Game-Based Learning Approach. *J. Educ. Comput. Res.* **2021**, *59*, 383–409. [CrossRef]
84. Klimova, N.; Sajben, J.; Lovaszova, G. Online Game-Based Learning through Minecraft: Education Edition Programming Contest. In Proceedings of the 2021 IEEE Global Engineering Education Conference (EDUCON), Vienna, Austria, 21–23 April 2021. [CrossRef]
85. Kroustalli, C.; Xinogalos, S. Studying the Effects of Teaching Programming to Lower Secondary School Students with a Serious Game: A Case Study with Python and CodeCombat. *Educ. Inf. Technol.* **2021**, *26*, 6069–6095. [CrossRef]
86. Montes, H.; Hijon-Neira, R.; Perez-Marin, D.; Montes, S. Using an Online Serious Game to Teach Basic Programming Concepts and Facilitate Gameful Experiences for High School Students. *IEEE Access* **2021**, *9*, 12567–12578. [CrossRef]
87. Polledo, E.; Garaizar, P.; Guenaga, M. Lempel: Developing the Pattern Recognition Skill in Computational Thinking through an Online Educational Game. In Proceedings of the CEUR Workshop Series, Virtual Conference, 20–22 June 2021; CEUR-WS: Aachen, Germany; pp. 28–30.
88. Saito, D.; Sakamoto, K.; Washizaki, H.; Fukazawa, Y.; Uchiyama, S.; Ramzi, R. Development of a Game to Foster Programming Thinking for Learning through Reading Programs. In Proceedings of the 2021 IEEE International Conference on Engineering, Technology & Education (TALE), Wuhan, China, 5–8 December 2021; pp. 183–187. [CrossRef]
89. Zapata-Caceres, M.; Martin-Barroso, E.; Roman-Gonzalez, M. Collaborative Game-Based Environment and Assessment Tool for Learning Computational Thinking in Primary School: A Case Study. *IEEE Trans. Learn. Technol.* **2021**, *14*, 576–589. [CrossRef]
90. Israel-Fishelson, R.; Hershkovitz, A. Persistence in a Game-Based Learning Environment: The Case of Elementary School Students Learning Computational Thinking. *J. Educ. Comput. Res.* **2020**, *58*, 891–918. [CrossRef]
91. Israel-Fishelson, R.; Hershkovitz, A. Shooting for the Stars. In *Early Warning Systems and Targeted Interventions for Student Success in Online Courses*; IGI Global: Hershey, PA, USA, 2020; pp. 239–258. [CrossRef]
92. Karakasis, C.; Xinogalos, S. BlocklyScript: Design and Pilot Evaluation of an RPG Platform Game for Cultivating Computational Thinking Skills to Young Students. *Inform. Educ.* **2020**, *19*, 641–668. [CrossRef]
93. Malva, L.; Hooshyar, D.; Yang, Y.; Pedaste, M. Engaging Estonian Primary School Children in Computational Thinking through Adaptive Educational Games: A Qualitative Study. In Proceedings of the 2020 IEEE 20th International Conference on Advanced Learning Technologies (ICALT), Tartu, Estonia, 6–9 July 2020; pp. 61–63. [CrossRef]
94. Sáiz Manzanares, M.C.; Rodríguez Arribas, S.; Pardo Aguilar, C.; Queiruga-Dios, M.A. Effectiveness of Self-Regulation and Serious Games for Learning STEM Knowledge in Primary Education. *Psicothema* **2020**, *32*, 516–524. [CrossRef]
95. Min, W.; Frankosky, M.H.; Mott, B.W.; Rowe, J.P.; Smith, A.; Wiebe, E.; Lester, J.C. DeepStealth: Game-Based Learning Stealth Assessment with Deep Neural Networks. *IEEE Trans. Learn. Technol.* **2020**, *13*, 312–325. [CrossRef]
96. Min, W.; Mott, B.; Park, K.; Taylor, S.; Akram, B.; Wiebe, E.; Lester, J. Promoting Computer Science Learning with Block-Based Programming and Narrative-Centered Gameplay. In Proceedings of the 2020 IEEE Conference on Games (CoG), Osaka, Japan, 21–24 August 2020; pp. 429–432. [CrossRef]

97. Mosquera, C.K.; Steinmaurer, A.; Eckhardt, C.; Guetl, C. Immersively Learning Object-Oriented Programming Concepts with sCool. In Proceedings of the 2020 6th International Conference of the Immersive Learning Research Network (iLRN), San Luis Obispo, CA, USA, 21–25 June 2020; pp. 60–67. [CrossRef]
98. Utesch, M.C.; Faizan, N.D.; Krcmar, H.; Heininger, R. Pic2Program—An Educational Android Application Teaching Computational Thinking. In Proceedings of the 2020 IEEE Global Engineering Education Conference (EDUCON), Porto, Portugal, 27–30 April 2020; pp. 1176–1181. [CrossRef]
99. Yallihep, M.; Kutlu, B. Mobile Serious Games: Effects on Students' Understanding of Programming Concepts and Attitudes Towards Information Technology. *Educ. Inf. Technol.* **2020**, *25*, 1237–1254. [CrossRef]
100. Koivisto, J.; Laru, J.; Mäkitalo, K.; Finland, C. Promoting Computational Thinking Skills in the Context of Programming Club for K-12 Pupils with the Engaging Game Adventure in Minecraft. In Proceedings of the International Conference on Computational Thinking Education 2019 (CTE2019), Hong Kong, China, 13–15 June 2019; pp. 1–6.
101. Krajcsi, A.; Csapodi, C.; Stettner, E. Algotaurus: An Educational Computer Programming Game for Beginners. *Interact. Learn. Environ.* **2019**, *29*, 634–647. [CrossRef]
102. Montes-Leon, H.; Hijon-Neira, R.; Perez-Marin, D.; Leon, S.R.M. Improving Programming Learning on High School Students through Educative Apps. In Proceedings of the 2019 International Symposium on Computers in Education (SIIE), Tomar, Portugal, 6–8 November 2019; pp. 1–6. [CrossRef]
103. Yücel, Y.; Rızvanoğlu, K. Battling Gender Stereotypes: A User Study of a Code-Learning Game, "Code Combat", with Middle School Children. *Comput. Hum. Behav.* **2019**, *99*, 352–365. [CrossRef]
104. Yuliana, I.; Octavia, L.P.; Sudarmilah, E.; Matahari, M. Introducing Computational Thinking Concept Learning in Building Cognitive Capacity and Character for Elementary Student. In Proceedings of the 2019 19th International Symposium on Communications and Information Technologies (ISCIT), Ho Chi Minh City, Vietnam, 25–27 September 2019; pp. 1–5. [CrossRef]
105. Zhao, W.; Shute, V.J. Can Playing a Video Game Foster Computational Thinking Skills? *Comput. Educ.* **2019**, *141*, 103633. [CrossRef]
106. Giannakoulas, A.; Xinogalos, S. A Pilot Study on the Effectiveness and Acceptance of an Educational Game for Teaching Programming Concepts to Primary School Students. *Educ. Inf. Technol.* **2018**, *23*, 2029–2052. [CrossRef]
107. Elmunsyah, H.; Kusumo, G.R.; Pujianto, U.; Prasetya, D.D. Development of Mobile-Based Educational Game as a Learning Media for Basic Programming in VHS. In Proceedings of the 2018 5th International Conference on Electrical Engineering, Computer Science and Informatics (EECSI), Malang, Indonesia, 16–18 October 2018; pp. 118–122. [CrossRef]
108. Videnovik, M.; Trajkovik, V. Using Scottie Go! as a Game-Based Learning Tool for Computational Thinking Course. In Proceedings of the ICERI 2018 Conference, Seville, Spain, 12–14 November 2018; pp. 7026–7033.
109. Zhi, R.; Lytle, N.; Price, T.W. Exploring Instructional Support Design in an Educational Game for K–12 Computing Education. In Proceedings of the 49th ACM Technical Symposium on Computer Science Education, Baltimore, MD, USA, 21–24 February 2018; pp. 400–405. [CrossRef]
110. Jakoš, F.; Verber, D. Learning Basic Programming Skills with Educational Games: A Case of Primary Schools in Slovenia. *J. Educ. Comput. Res.* **2017**, *55*, 673–698. [CrossRef]
111. Lindberg, R.S.N.; Hasanov, A.; Laine, T.H. Improving Play and Learning Style Adaptation in a Programming Education Game. In Proceedings of the 9th International Conference on Computer Supported Education (CSEDU), Porto, Portugal, 21–23 April 2017; pp. 450–457. [CrossRef]
112. Liu, Z.; Zhi, R.; Hicks, A.; Barnes, T. Understanding Problem-Solving Behavior of 6–8 Graders in a Debugging Game. *Comput. Sci. Educ.* **2017**, *27*, 1–29. [CrossRef]
113. Sorrentino, F.; Spano, L.D.; Casti, S.; Carcangiu, A.; Corda, F.; Cherchi, G.; Scateni, R. ChIP: Teaching Coding in Primary Schools. In *CEUR Workshop Proceedings*; CEUR-WS: Aachen, Germany, 2017; Volume 1910, pp. 106–110.
114. Freeman, B.; Higgins, K. A Randomised Controlled Trial of a Digital Learning Game in the Context of a Design-Based Research Project. *Int. J. Technol. Enhanc. Learn.* **2016**, *8*, 297. [CrossRef]
115. Horn, B.; Clark, C.; Strom, O.; Chao, H.; Stahl, A.J.; Harteveld, C.; Smith, G. Design Insights into the Creation and Evaluation of a Computer Science Educational Game. In Proceedings of the 47th ACM Technical Symposium on Computing Science Education, Memphis, TN, USA, 17–20 February 2016; pp. 276–281. [CrossRef]
116. Saito, D.; Washizaki, H.; Fukazawa, Y. Analysis of the Learning Effects Between Text-Based and Visual-Based Beginner Programming Environments. In Proceedings of the 2016 IEEE 8th International Conference on Engineering Education (ICEED), Kuala Lumpur, Malaysia, 7–8 December 2016; pp. 191–196. [CrossRef]
117. Lehat, M.L.; Mokhtar, R.; Sokman, Y.; Ismail, M.I.; Basir, N.M. Games: An Approach to Introduce Computer Programming for Upper Primary School Students. In Proceedings of the 2014 3rd International Conference on User Science and Engineering (i-USEr), Shah Alam, Malaysia, 2–4 September 2014; pp. 160–164. [CrossRef]
118. Pellas, N. Exploring Interrelationships Among High School Students' Engagement Factors in Introductory Programming Courses via a 3D Multi-User Serious Game Created in OpenSim. *J. Univ. Comput. Sci.* **2014**, *20*, 1608–1628.

119. Paliokas, I.; Arapidis, C.; Mpimpitsos, M. PlayLOGO 3D: A 3D Interactive Video Game for Early Programming Education: Let LOGO Be a Game. In Proceedings of the 2011 Third International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES 2011), Athens, Greece, 4–6 May 2011; pp. 47–54. [CrossRef]
120. González, M.R. Computational Thinking Test: Design Guidelines and Content Validation. In Proceedings of the EDULEARN15, Barcelona, Spain, 6–8 July 2015; pp. 2436–2444.
121. Park, S.Y. An Analysis of the Technology Acceptance Model in Understanding University Students' Behavioral Intention to Use E-Learning. *J. Educ. Technol. Soc.* **2009**, *12*, 150–161.
122. Morrison, B.B.; Dorn, B.; Guzdial, M. Measuring Cognitive Load in Introductory CS: Adaptation of an Instrument. In Proceedings of the Tenth Annual Conference on International Computing Education Research, Glasgow, Scotland, 11–13 July 2014; pp. 131–138.
123. MacLeod, J.; Yang, H.H.; Xiang, Z. Understanding College Students' Intrinsic Motivation and Social Interdependence in Intercultural Computer-Supported Collaborative Learning Between USA and China. *Asia-Pac. Educ. Res.* **2017**, *26*, 205–217. [CrossRef]
124. Grover, S. *Foundations for Advancing Computational Thinking: Balanced Designs for Deeper Learning in an Online Computer Science Course for Middle School Students*; Stanford University: Stanford, CA, USA, 2014.
125. IJsselsteijn, W.A.; De Kort, Y.A.; Poels, K. The Game Experience Questionnaire. In *Technical Report*; Eindhoven University of Technology: Eindhoven, The Netherlands, 2013.
126. Law, E.L.C.; Brühlmann, F.; Mekler, E.D. Systematic Review and Validation of the Game Experience Questionnaire (GEQ)—Implications for Citation and Reporting Practice. In Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play, Melbourne, Australia, 28–31 October 2018; pp. 257–270. [CrossRef]
127. Zhang, S.; Wong, G.K.W.; Chan, P.C.F. Achievement and Effort in Acquiring Computational Thinking Concepts: A Log-Based Analysis in a Game-Based Learning Environment. In Proceedings of the Fifth APSCE International Conference on Computational Thinking and STEM Education 2021 (CTE-STEM), Hong Kong, China, 16–18 June 2021.
128. Zhang, S.; Wong, G.K.W.; Sun, X. Exploring Coding Attitudes of Chinese Elementary Students: A Preliminary Study. In Proceedings of the 2022 IEEE Integrated STEM Education Conference (ISEC), Princeton, NJ, USA, 26 March 2022.
129. Zapata-Cáceres, M.; Martín-Barroso, E.; Román-González, M. Computational Thinking Test for Beginners: Design and Content Validation. In Proceedings of the 2020 IEEE Global Engineering Education Conference (EDUCON), Porto, Portugal, 27–30 April 2020; pp. 1905–1914. [CrossRef]
130. Högberg, J.; Hamari, J.; Wästlund, E. Gameful Experience Questionnaire (GAMEFULQUEST): An Instrument for Measuring the Perceived Gamefulness of System Use. *User Model. User-Adap. Interact.* **2019**, *29*, 619–660. [CrossRef]
131. Petri, G.; von Wangenheim, C.G.; Borgatto, A.F. MEEGA+: An evolution of a model for the evaluation of educational games. *INCoD GQS* **2016**, *3*, 1–40.
132. Chen, G.; Gully, S.M.; Eden, D. Validation of a New General Self-Efficacy Scale. *Organ. Res. Methods* **2001**, *4*, 62–83. [CrossRef]
133. Wiebe, E.; Williams, L.A.; Yang, K.; Miller, C.S. *Computer Science Attitude Survey*; North Carolina State University, Department of Computer Science: Raleigh, NC, USA, 2003.
134. Appianing, J.; Van Eck, R.N. Development and Validation of the Value-Expectancy STEM Assessment Scale for Students in Higher Education. *Int. J. STEM Educ.* **2018**, *5*, 24. [CrossRef] [PubMed]
135. Brooke, J. SUS: A Quick and Dirty Usability Scale. In *Usability Evaluation in Industry*; Jordan, P.W., Thomas, B., Weerdmeester, B.A., McClelland, A.L., Eds.; Taylor & Francis: London, UK, 1996; pp. 189–194.
136. 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]
137. Liu, E.Z.F.; Lee, C.Y.; Chen, J.H. Developing a New Computer Game Attitude Scale for Taiwanese Early Adolescents. *J. Educ. Technol. Soc.* **2013**, *16*, 183–193.
138. Lampropoulos, G.; Sidiropoulos, A. Impact of Gamification on Students' Learning Outcomes and Academic Performance: A Longitudinal Study Comparing Online, Traditional, and Gamified Learning. *Educ. Sci.* **2024**, *14*, 367. [CrossRef]
139. Yu, Z.; Gao, M.; Wang, L. The Effect of Educational Games on Learning Outcomes, Student Motivation, Engagement and Satisfaction. *J. Educ. Comput. Res.* **2021**, *59*, 522–546. [CrossRef]
140. Lampropoulos, G.; Kinshuk. Virtual Reality and Gamification in Education: A Systematic Review. *Educ. Technol. Res. Dev.* **2024**, *72*, 1691–1785. [CrossRef]
141. Hartt, M.; Hosseini, H.; Mostafapour, M. Game on: Exploring the Effectiveness of Game-Based Learning. *Plann. Pract. Res.* **2020**, *35*, 589–604. [CrossRef]
142. Lampropoulos, G.; Keramopoulos, E.; Diamantaras, K.; Evangelidis, G. Integrating Augmented Reality, Gamification, and Serious Games in Computer Science Education. *Educ. Sci.* **2023**, *13*, 618. [CrossRef]

143. Lampropoulos, G. Educational Benefits of Digital Game-Based Learning: K-12 Teachers' Perspectives and Attitudes. *Adv. Mobile Learn. Educ. Res.* **2023**, *3*, 805–817. [CrossRef]
144. Kravik, R.; Berg, T.K.; Siddiq, F. Teachers' Understanding of Programming and Computational Thinking in Primary Education—A Critical Need for Professional Development. *Acta Didact. Nord.* **2022**, *16*, 23. [CrossRef]

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