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REVIEW

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# Game-based learning in computer science education: a scoping literature review

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**Abstract**

Using games in education has the potential to increase students' motivation and engagement in the learning process, gathering long-lasting practical knowledge. Expanding interest in implementing a game-based approach in computer science education highlights the need for a comprehensive overview of the literature research. This scoping review aims to provide insight into current trends and identify research gaps and potential research topics concerning game-based learning in computer science. Using standard methodology for scoping review, we identified 113 articles from four digital libraries published between 2017 and 2021. Those articles were analyzed concerning the educational level, type of the game, computer science topic covered by the game, pedagogical strategies, and purpose for implementing this approach in different educational levels. The results show that the number of research articles has increased through the years, confirming the importance of implementing a game-based approach in computer science. Different kinds of games, using different technology, concerning different computer science topics are presented in the research. The obtained results indicate that there is no standardized game or standardized methodology that can be used for the creation of an educational game for computer science education. Analyzed articles mainly implement a game-based approach using learning by playing, and no significant focus is given to the effectiveness of learning by designing a game as a pedagogical strategy. Moreover, the approach is mainly implemented for developing computational thinking or programming skills, highlighting the need for its implementation in other topics beyond programming.

**Keywords** Scoping review, Game-based learning, Educational games, Computer science, Computer science education

## Introduction

The world is changing very fast due to the emergence of technology in our everyday lives. This tremendous change can be noticed in different areas, including education. Students are influenced by the digital era, surrounded by technology and working with a massive amount of digital information on an everyday base. They are used to interactive environments and fast communication and prefer learning by doing (Unger & Meiran, 2020). Traditional learning environments, where students should sit and listen to the information provided by the teachers are unacceptable for them (Campbell, 2020). Students require active learning environments, using the possibilities of various technology applications to gain knowledge. They seek more interesting, fun, motivating and engaging learning experiences (Anastasiadis et al., 2018).

Creating engaging learning environments can develop students' critical thinking, problem-solving skills, creativity and cooperation, preparing students for living in

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a constantly changing world (Joshi et al., 2022; Lapek, 2018; Tang et al., 2020). Education needs to shift toward active learning approaches that will encourage students to engage on a deeper level than traditional lecture-based methods (Boyer et al., 2014). To achieve this, teachers must find an approach tied to digital tools that students use daily (Videnovik et al., 2020).

### Implementation of a game-based learning approach for creating engaging learning environments

Game-based learning is considered one of the most innovative learning approaches for increasing students' interest in education by playing games (Priyaadharshini et al., 2020). It refers to using games as an educational tool or strategy to facilitate learning and engagement (Li et al., 2021). Game-based learning involves designing and incorporating educational content within a game format, where players actively participate and interact with the game mechanics to acquire knowledge or develop skills. Many approaches tackle the umbrella of application of game-based learning in different educational fields. Different playful experiences can enable children to construct knowledge by playing and exploring a real-world problem often driven by students' interest in inquiry (Hirsh-Pasek, 2020). Gamification is a process that uses game elements, such as points, rewards, badges and competition during the learning process, establishing interactive and engaging learning environments (Turan et al., 2016). Gamification aims to enhance motivation, engagement, and participation using the inherent appeal of games. Designing interactive and entertaining games, primarily for education, is a step forward in implementing game-based learning. Serious games enable players to cultivate their knowledge and practice their skills by overcoming numerous interruptions during gaming (Yu, 2019). Effectively designed serious games facilitate learning by stimulating creativity, igniting interest, promoting discourse, and cultivating a competitive drive for exploration in diverse fields. Different mobile and location-based technologies provide opportunities to embed learning in authentic environments and thereby enhance engagement and learning outside traditional formal educational settings (Huizenga et al., 2009). Those games can simulate various aspects of reality, such as driving a vehicle, managing a city, or piloting an aircraft, allowing players to experiment and make decisions in a safe space without real-world consequences (Toh & Kirschner, 2020).

Games enable the integration of intrinsic and extrinsic motivational components to create an environment, where players feel more motivated to engage in the activities (Hartt et al., 2020). When digital game-based learning is implemented, including key game design elements (collaboration, choice, feedback), there is typically a positive impact on student engagement (Serrano, 2019; Wang et al., 2022). Students approach gameplay with interest and dedication and are persistent in progressing it. Therefore, teachers must find different ways to implement a game-based approach in the classroom, utilizing students' engagement, persistence and motivation during gameplay for classroom activities. During game-based learning, students have fun and enjoy themselves with increased imagination and natural curiosity, which can lead to high levels of participation and the student's involvement in the learning process. In this way, students can be more successfully engaged in meaningful learning than traditional teaching methods (Hamari et al., 2016; Huizenga et al., 2009; Karram, 2021).

### Research on using a game-based learning approach in education

In the last decade, the game-based approach is receiving increasing attention in the research community due to its potential to increase students' motivation and engagement, promoting a student-centred learning environment. Many researchers show that digital game-based learning is becoming a powerful tool in education, making learning more enjoyable, easier and efficient (Boyle et al., 2016; Hafeez, 2022). Implementation of a game-based learning approach can provide students with an engaging, motivating and stimulating environment (Ghergulescu & Muntean, 2012; Hwang et al., 2014), supporting them to focus on the task and increasing overall learning experiences (Hamari et al., 2016). Moreover, game-based learning has the potential to improve students' competencies and academic performance (Clark et al., 2016; López-Fernández et al., 2021a, 2021b; Mezentseva et al., 2021; Noroozi et al., 2020; Sanchez Mena & Martí-Parreño, 2017; Vu & Feinstein, 2017). It presents the learners with rich, immersive environments and experiences that are not just about learning facts but enables the development of problem-solving, decision-making, and strategic planning (Lymbery, 2012; Sung & Hwang, 2013) skills. In addition, the student's academic achievement using a game-based approach is better than those learning through the traditional method (Arcagök, 2021; Partovi & Razavi, 2019; Roodt & Ryklief, 2022; Wang et al., 2022). Educational games promote active and self-directed learning, enabling students to learn from authentic situations and receive immediate feedback (Pellas & Mystakidis, 2020; Zhao et al., 2021). It can be highly personalized, allowing students to learn at their own pace and in a way best suited to their individual needs and learning styles, engaging them in the self-assessment process (Videnovik et al., 2022). In a gaming environment, students can explore different scenarios,

make choices, and learn from the consequences of their actions without fear of making a mistake.

Despite the great potential of the game-based approach for learning, it must be noted that developing educational games can be very complex and costly, and faces significant challenges (Boyle et al., 2016). The process of designing an educational game needs a lot of planning and requires a lot of skills (Hussein et al., 2019). Teachers do not have necessary skills to develop a game that combines entertainment and educational elements to increase student's interest and motivation during learning (Qian & Clarck, 2016). On the other side, game developers have problem to align educational goals within the game. In addition, the games must be well-designed and with the right level of complexity so the learners should not be bored or frustrated during the play (Liu et al., 2020; Vlahu-Gjorgievska et al., 2018), taking into account both educational and entertainment elements. That is why educators cannot depend solely on professional game designers and must take on the responsibility of creating these immersive learning experiences themselves or by engaging their students in the design process.

### Game-based learning approach in computer science education

The game-based approach provides a dynamic and effective way for students to learn and apply their knowledge in a variety of subjects, such as math (Vankúš, 2021), physics (Cardinot & Fairfield, 2019), languages (Lee, 2019), and history (Kusuma et al., 2021). This approach allows students to learn complex concepts and skills in a fun and interactive way while also fostering critical thinking and collaboration. It is particularly effective in computer science, where students can learn about algorithms, data structures, networks, software testing and programming languages by designing and testing their games and simulations (Kalderova et al., 2023). In addition, game-based learning can help to bridge the gap between theory and practice, allowing students to apply their knowledge in a real-world context (Barz et al., 2023).

The importance of computer science has been emphasized in the last decade through different campaigns and online platforms. Their main aim is to develop students' computational thinking skills and attract students to coding, mainly through a game-based approach (code.org, codeweek.org). They offer teachers access to materials and learning scenarios covering different unplugged activities and block-based programming. Students have an opportunity to play games and learn basic programming concepts through fun and interactive activities, developing collaboration and competitiveness at the same time. Game narratives, collecting points, and immediate feedback through these games increase students' engagement. These platforms are a valid option for developing computational thinking at an early age and a good way for students to develop creativity, critical thinking and problem-solving skills (Barradas et al., 2020).

Various block-based programming languages, which are also accessible online (Scratch,[1] Snap,[2] Blockly[3]), are used to develop students' computational thinking and block-based programming skills, especially in primary education. In addition, they support the development of interactive projects that students can use afterward (Tsur & Rusk, 2018). Moreover, students can develop animations, interactive stories, and games, which allow them to engage in the coding process, learn programming concepts and even learn about other computer science topics during game design.

Topics connected with programming are the most common in computer science, but learning how to program is often recognized as a frustrating activity (Yassine et al., 2018). Learning object-oriented programming languages is especially difficult for students, because programming concepts are complex, cognitively demanding, require algorithmic thinking and problem-solving skills, and is a long-term process (Zapušek & Rugelj, 2013). Game-based learning stimulates active learning and enables students to learn about programming concepts in fun and engaging ways through visual interfaces and engaging environments (CodeCombat,[4] Alice,[5] Greenfoot[6]). Those engaging and motivating environments enable simplifying complex programming concepts, such as inheritance, nested loops, and recursion (Karram, 2021).

Different pedagogical strategies can be used to implement game-based learning in computer science, empowering students' skills and increasing their active engagement in learning. For example, students can deepen their knowledge and skills on a given topic by playing the game (Hooshyar et al., 2021; Shabalina et al., 2017) or through the process of game design (Denner et al., 2012; Zhang et al., 2014). In both cases, the game-based approach can increase students' motivation and engagement in learning (Chandel et al., 2015; Park et al., 2020).

[1] https://scratch.mit.edu/

[2] https://snap.berkeley.edu/

[3] https://blockly.games/

[4] https://codecombat.com/

[5] https://www.alice.org/

[6] https://greenfoot.org/door

**Table 1** Review articles concerning the implementation of game-based approach in computer science

| Title | References | Outcomes |
|---|---|---|
| A systematic review of learning object-oriented programming through serious games and programming approaches | Abbasi et al. (2017) | Systematic literature review identifying serious games developed or incorporated for learning object-oriented programming, object-oriented programming concepts covered in those games, and programming approaches applied |
| Serious games to prevent and detect bullying and cyberbullying: A systematic serious games and literature review | Calvo-Morata et al. (2020) | The systematic literature review focused on the use of video games as tools for the prevention and detection of bullying and cyberbullying |
| Fostering computational thinking through unplugged activities: A systematic literature review and meta-analysis | Cheng et al. (2023) | Systematic review and meta-analyses summarizing the effect of unplugged activities on enhancing students' computational thinking skills |
| Evaluating Aspects of Usability in Video Game-Based Programming Learning Platforms | Diaz et al. (2021) | Scoping review of video game platforms that can be used for developing of programming skills |
| A Systematic Mapping Study on Game Elements and Serious Games for Learning Programming | Dos Santos et al. (2019) | Systematic review about serious games for learning programming, game elements and methods for their evaluation |
| Game-Based Information Security/Privacy Education and Awareness: Theory and Practice | Karagiannis et al. (2020) | Reviewing of methods and tools for deploying a game-based approach for security/privacy learning and awareness, and their assessment |
| A comparative analysis of programming games, looking through the lens of an instructional design model and a game attributes taxonomy | Laporte and Zaman (2018) | Qualitative, comparative analysis of 19 programming games from an instructional and game attributes perspective |
| A Review of Gamification for Learning Programming Fundamental | Shahid et al. (2019) | Scoping review of the existing literature of serious programming games, identifying game elements that should be included to ensure students' active participation |
| Improving girls' perception of computer science as a viable career option through game playing and design: Lessons from a systematic literature review | Sharma et al. (2021) | Systematic literature review about the relation between the various games playing or designing activities and their impact on girls' perception of computer science as a career choice |
| Cyber security training a survey of serious games in cyber security | Tioh et al. (2017) | A survey about background as well as the current state of serious games dealing specifically with the topic of cybersecurity |

### Existing reviews of game-based approach in computer science

Existing reviews of game-based approach in computer science provide valuable information about the latest trends in the implementation of game-based approach in the last few years. Table 1 presents latest trends in the implementation of game-based learning in computer science education.

Most of the review articles analyze publications that describe the implementation of game-based approach for learning programming (Abbasi et al., 2017; Diaz et al., 2021; Dos Santos et al., 2019; Laporte & Zaman, 2018; Shahid et al., 2019), from different aspects: game design, game elements, or their evaluation. However, there are some of them tackling other topics, such as cybersecurity (Karagiannis et al., 2020; Tioh et al., 2017) or cyberbullying (Calvo-Morata et al., 2020). Sharma et al. (2021) analyzes the impact of game-based learning on girls' perception toward computer science. There are review articles that focus on just one aspect of computer science. For example, Chen et al. (2023) provides meta-analyses to investigate potential of unplugged activities on computational thinking skills.

In our review, we aim to perform the broader analysis of the research articles referring to the game-based approach in various computer science topics, different educational levels and different types of games. For that purpose, instead of systematic review, we have opted to perform the scoping review on significantly larger set of articles.

Valuable insight regarding the game-based approach in computer science has been provided in research concerning different educational levels, computer science topics, and used games. However, computer science is a field that is changing very fast, and the number of games that can be used for developing students' knowledge and skills is increasing all the time. As a result, continuous research in this field should be done.

This research aims to elaborate on current trends concerning the game-based approach in computer science. It focuses on the educational level, covered computer science topic, type of the game, purpose for its use, and pedagogical strategies for the implementation of this approach. Moreover, possible gaps and potential research topics concerning game-based learning in computer science in primary education are identified.

## Current review

This research represents scoping review that identifies the educational context and the type of games used for implementing a game-based learning approach in computer science. The scoping review method was selected over systematic literature review, because we wanted to determine the scope of the literature in the field of game-based learning in computer science education, to examine how research is done on this topic and to identify and analyze research gaps in the literature (Munn et al., 2018).

Following Arksey and O'Malley (2005) five-step framework, which adopts a rigorous process of transparency, enabling replication of the search method and increasing the reliability of the results, the steps of the applied review process are: to (1) identify research questions (2) identify relevant studies, (3) study selection of papers, (4) charting the data, (5) summarizing and reporting the results.

### Research questions

The focus of our research was to analyze what type of games were used in computer science, the subject's topics that were covered by the game and pedagogical strategies for implementing game-based learning, comparing all these in different educational levels. Starting from this, our research questions are:

RQ1: What kind of educational games are usually used during the implementation of the game-based approach in computer science?

Various games are used to cover topics from computer science, from block-based serious games (Vahldick et al., 2020) to educational escape rooms (López-Pernas et al., 2019). Using different games influences the learning process differently (Chang et al., 2020). The RQ1 seeks to identify and understand the types of educational games that are commonly utilized in the context of teaching computer science. Exploration of the variety of used games provides insights into the different approaches, mechanics, and formats used to enhance learning outcomes.

RQ2: Which pedagogical strategy is mostly used in the published research?

There are various strategies for implementing game-based learning in computer science education. The implementation strategies refer to whether students should learn by playing the game (Malliarakis et al., 2014) or by designing a game (Denner et al., 2012). The strategies can differ based on the gender of students (Harteveld et al., 2014), students' age (Bers, 2019), or the adopted approach by policymakers (Lindberg et al., 2019). RQ2 aims to identify the predominant pedagogical strategy employed in the published research on game-based approaches in computer science education. By examining the pedagogical strategies, researchers can gain insights into the most effective instructional methods that facilitate learning through game-based approaches. Furthermore, the findings can inform educators and researchers in designing and implementing effective instructional

strategies that align with the goals of computer science education.

RQ3: Which computer science topics are covered by the game-based approach?

Game-based learning can be used to teach different computer science topics, from introduction topics (Fagerlund et al., 2021; Mathew et al., 2019), to core topics (Karram, 2021). RQ3 aims to provide value in exploring the specific computer science topics addressed through game-based approaches. In addition, it helps identify the range of topics that have been integrated into educational games. By understanding the computer science topics covered, researchers can assess the breadth and depth of the game-based approach and identify potential gaps or areas for further exploration in the curriculum.

RQ4: What are the potential research topics concerning the implementation of a game-based approach in computer science?

RQ4 is essential as it seeks to identify potential areas for future research in the implementation of game-based approaches in computer science education. It might include specific computer science topics (Calvo-Morata et al., 2020), strategies to implement game-based learning in computer science (Hooshyar et al., 2021), or ways to analyze the effects of game-based learning (Scherer et al., 2020). By exploring research topics that have not been extensively studied or require further investigation, researchers can identify new directions and opportunities for advancing the field. This can contribute to the ongoing development and improvement of game-based approaches in computer science education, fostering innovation and addressing emerging challenges.

## Methodology

To answer research questions, we analyzed the contents of articles published from 2017 to 2021. Due to the rapid development of technology and change in the learnt computer science topics as well as designed game with new technology and tools, we have decided to research the articles that refer just to the interval of 5 years. As technology progresses swiftly, studying 5 year interval of the published literature ensures that scoping review results analyze the most current tools, approaches, and methodologies being utilized in the field of computer science education.

The research was done according to the PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews) guidelines (Peters et al., 2020). The PRISMA-ScR methodology is a structured approach used to conduct comprehensive and transparent scoping reviews. It involves identifying a research question, performing a systematic search of relevant literature, applying inclusion and exclusion criteria to select studies, extracting data from the included studies, analyzing and synthesizing the data to identify key themes or patterns, and reporting the findings. It aims to map the existing literature on a particular topic, identify key concepts, and examine the extent, range, and nature of research available. It is particularly useful for exploring complex and diverse research questions.

There is a large number of articles regarding the topic, so performing this kind of research manually seemed like labor-intensive work. Therefore, we have identified the opportunity to use the Natural Language Processing (NLP) toolkit (Zdravevski et al., 2019) to automate the literature search, scanning, and eligibility assessment. We have used this toolkit for article identification and selection (i.e., scanning procedures and eligibility criteria assessment). The search considered articles indexed in four digital libraries: IEEE, PubMed, Springer and Elsevier. The NLP toolkit requires structured data input comprising keywords, properties, property groups, required relevance, included sources, and start and end years.

The provided keywords serve as search criteria within available libraries, acting as the primary filter to determine which articles will be gathered for further analysis. At the beginning of setting up the NLP toolkit for the research, to address different games that can be used in education, we have identified the main keywords to be "Serious Games", "Educational Games", "Games in education" or "Games for learning". The NLP toolkit used these keywords to identify the potentially relevant articles in the mentioned digital libraries.

Furthermore, the NLP toolkit was adjusted to search specific properties (words or phrases) within the title, abstract, or keywords of already identified articles to select relevant articles in more detail, according to the features (properties groups) of the game-based learning approach that we are interested in: subject, educational level, educational context, purpose and used technology. Properties groups address synonyms and various versions of the phrase (e.g., educational games and serious games). To be included in the results, at least one representative from each property group must appear in the title or abstract of the article, thereby functioning as a secondary filter for identifying relevant articles.

The property group "subject" was set as mandatory during the search, because we were interested in analyzing articles that refer to game-based learning just in computer science. Since the name of this subject is different in different countries, we have used synonyms, such as "programming", "coding", and "informatics". The property group "age" or educational level included different synonyms for primary and secondary education, as well as higher education, although we did not make this

**Table 2** NLP toolkit input parameters: keywords, properties, and property groups

| Input parameter | Natural language processing toolkit input parameters | |
|---|---|---|
| Keyword | Serious Games OR Educational Games OR Games in education OR Games for learning | |
| Property Group | Subject | Computer Science, programming, coding, informatics |
| | Age | primary education, K12, primary school, pupils, elementary school, secondary education, high school, adolescents, teenagers, secondary school, university |
| | Purpose | engagement, Quality of Experience, educational evaluation, learning achievement, interest, motivation, game evaluation |
| | Technology | Web, online, mobile, augmented reality, virtual reality |

property mandatory. To search about the used technology (web, online, mobile, augmented reality, virtual reality), we have set one property group to include a different kind of used technology, and we also set a property group that refers to the aim of using these educational games (to achieve students' engagement, increase motivation, evaluation of educational results, etc.). A more detailed description of the properties groups is given in Table 2.

The following input parameter for the NLP toolkit setup is the minimum relevant properties. In this research, it was set that each article has to contain a minimum of two of the previously defined properties to be considered relevant. The quality analysis of the relevant articles followed in the next step of the methodology.

### Study selection

The initial search in four digital libraries: IEEE, PubMed, Springer and Elsevier, has identified 43,885 articles concerning using game-based learning in computer science. After articles had been identified based on the specified keywords and retrieved from the publishers, the duplicates were identified according to the article DOI as their unique identifier and removed, which has decreased the number of articles to 21,002. In the next step, the articles selection (screening and eligibility assessment) procedures followed, discarding articles not published in the required period or for which the title or abstract could not be analyzed because of parsing errors, unavailability, or other reasons. The screening process eliminated 11,129 articles and the remaining 9873 articles underwent an automated eligibility assessment using the advanced NLP toolkit functionalities. The automated eligibility analysis involved the following processing: tokenization of sentences (Manning et al., 2014; Webster et al., 1992) and English stop words removal, stemming, and lemmatization using the Natural Language Toolkit library (Bird, 2006). Furthermore, articles containing less than two properties were removed, which left 1209 articles eligible for further manual analysis and inclusion in identifying the research trends and summarizing the results.

For each of the articles from the collection of relevant articles, the toolkit automatically generated a bibliographic file (as defined by BibTeX reference management software). This file was manually analyzed in more detail to identify the most relevant articles for the purpose of our study. First, the abstract was read to see whether the article was relevant, and if that did not provide enough information, the whole article was read. For each of the research questions we used the same approach, but with different focuses. For the first research question, we looked for any specific game name. For the second research question, we were looking for any mentioning of the pedagogical approaches or strategies. For the third research question, we looked for different computer science topics used in computer science curricula. In that way, the most relevant articles concerning first three research questions were identified. The last research question is related to future potential research topics in the field of game-based learning in computer science education, so it was not used during this phase of selection of relevant articles.

As a result of the manual analysis of articles' titles, articles that did not refer to computer science subjects were excluded, which left just 206 articles. We could not obtain the full text for some of articles, so they were excluded from further analyses. Some articles did not refer to using games to teach computer science topics, so they were also removed. The same was the case with a few articles not written in English. Finally, we had 125 relevant articles.

Nine relevant articles were review papers that referred to different game-based learning approaches at different educational levels. Among identified articles is a book describing different teaching methods in computer science education, including game-based learning (Hazzan et al., 2020). Two book chapters refer to different approaches of using game-based learning in education (Bellas et al., 2018; Zaw & Hlaing, 2020). These articles were also excluded from the list.

Finally, we finished the selection process and got 113 relevant articles using educational games in computer science that were the subject of further analysis.

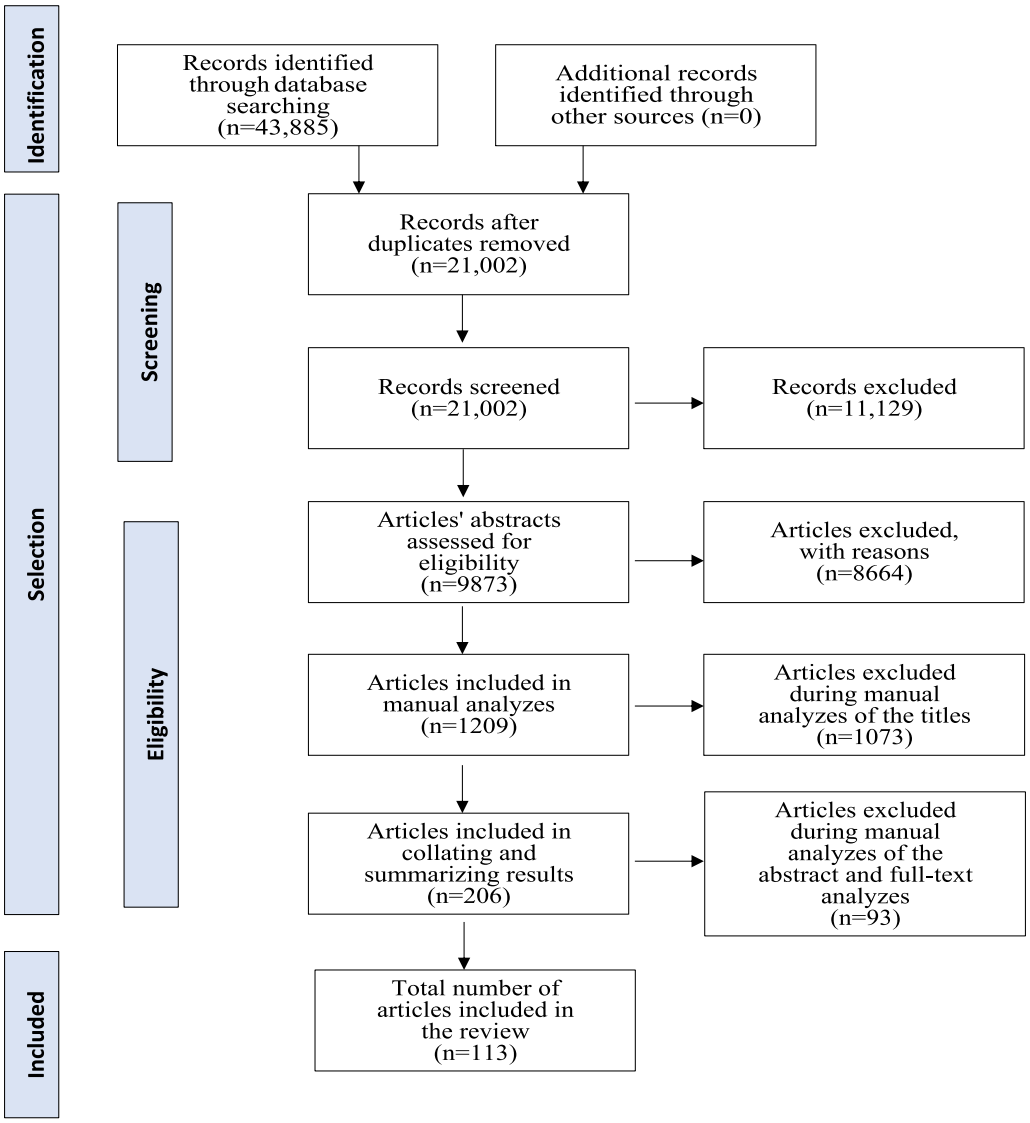


**Fig. 1** Flowchart of the PRISMA-SCR-based selection process

The information flowchart presenting the numbers of identified, screened, processed, and removed articles in the automated NLP procedure and articles removed during the manual analysis is presented in Fig. 1.

After the final identification of the most relevant studies concerning game-based learning in computer science, summaries were developed for each article. Information about their correspondence to education, educational level, used game, type of the game, covered computer science topic, educational context and general usefulness of the article was provided.

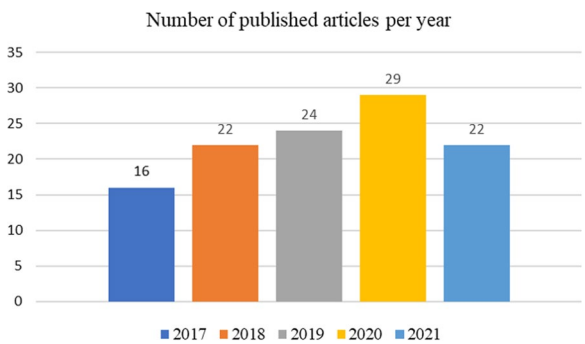


**Fig. 2** Distribution of the published articles through the years

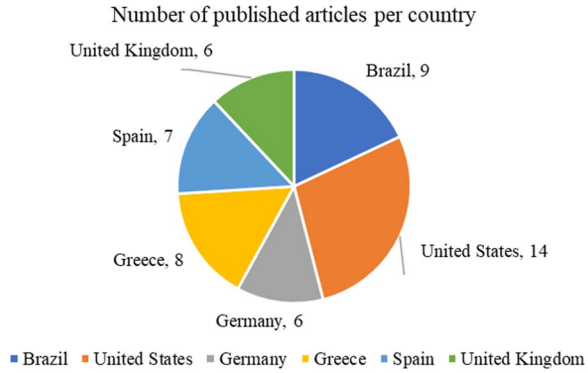


**Fig. 3** Distribution of the published articles per country, showing countries with more than five published articles

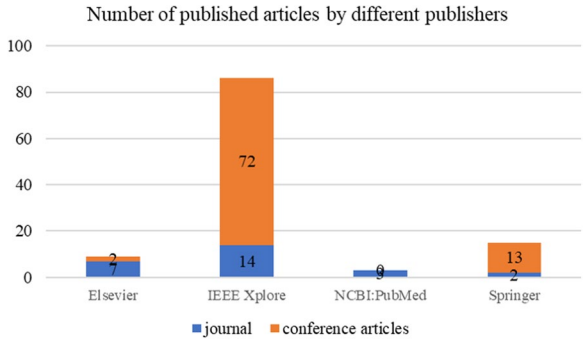


**Fig. 4** Distribution of the published articles by different publishers

## Results

### Distribution of published articles through the years

The distribution of the articles concerning the game-based approach in computer science through the years is presented in Fig. 2. It can be noticed that the number of articles was increasing through the years, but then suddenly, in 2021, that number decreased. The reason might be found in the situation with the pandemic, because in 2020 and 2021, most of the schools were closed. In some of them, the teaching was transferred online, which resulted in a huge change in the way of teaching and learning, and it was a period of adaptation for teachers and students at the same time, which might lead to a decrease of the research articles.

### Distribution of published articles per country

The distribution of the published articles per country differs from country to country. Figure 3 presents the distribution of published articles per country, showing only the countries that have more than five published articles concerning game-based learning between 2017 and 2021. Most articles are published in the United States, followed by Brazil and Greece.

Further analysis of the relevant articles depending on the country, where the research was conducted, shows that just 17 (of 113) articles are joint work of researchers from different countries. Moreover, just two present joint research on game-based learning from three countries. The first one describes the methodology implemented within the European initiative Coding4girls, which proposes to teach coding through a game design based on a design thinking methodological approach linked to creativity and human-centred solutions (De Carvalho et al., 2020). The second joint research (Agbo et al., 2021) describes the students' online co-creation of mini-games to develop their computational thinking skills. Interestingly, all other published articles describe implementing a game-based learning approach in computer science in the local context, making it difficult to generalize the conclusions and the research outcomes.

### Distribution of published articles by publisher

Most of the relevant researched articles are published by IEEE Xplore (86 of 113) but mostly published as part of the proceedings at different conferences. This might explain why the number of published articles from IEEE Xplore differs from other publishing companies. Figure 4 presents the distribution of the articles by each of the publishers in detail, comparing published articles in journals and at conferences.

### Distribution of published articles by educational level

Identifying the number of articles according to the educational level was more complicated due to the different educational systems in different countries, resulting in a different understanding of the terms "primary", and "secondary" education. In some countries, the same educational level is entitled as "primary", and in others as "lower secondary" or even "middle school". For example, in some countries, the primary school includes 6–14-year-old students; in others, it is divided, so there are primary (from 6 to 10 years), middle (11–13 years) and high schools (14–18 years); and in some, there are even lower secondary school (12–16 years). Therefore, we have tried to combine different categories according to the student's age and to gather three levels: primary, secondary and university, according to the local context (primary education includes 6–14 years, secondary education includes 15–18 years). The situation with the distribution of the relevant articles is presented in Fig. 5.

It can be noticed that most of the articles concern universities, although the number of articles that concern using games in computer science in primary and secondary schools is not small. It can be expected, because most of the articles refer to using games for developing

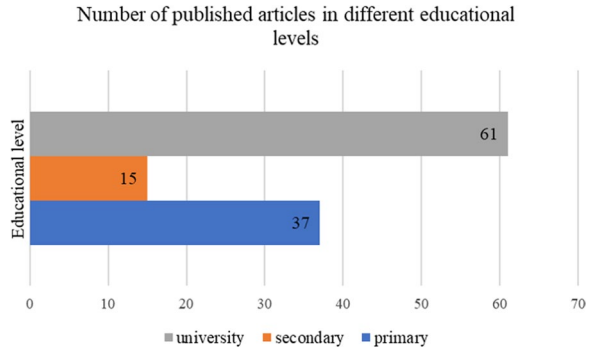


**Fig. 5** Distribution of the published articles in different educational levels

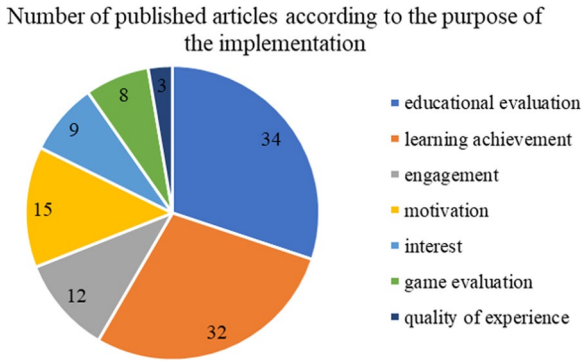


**Fig. 6** Distribution of the published articles according to the purpose of the implementation

programming skills, which is present mainly at the university level. However, in some countries, primary school students learn fundamental programming concepts.

### Distribution of published articles by the purpose of implementation

The purpose of the research concerning game-based learning in computer science is different and mostly depends on the type of the game as well as the topic that is covered by the game. The distribution of the published articles according to the purpose of the implementation of the research is presented in Fig. 6. However, it must be mentioned that it was difficult to distinguish the purposes of implementing the game-based approach in computer science, because the purpose was not clearly stated in the articles or there was overlapping among different categories.

In the most articles (66 of 113), the research is done to measure students' learning achievement or to evaluate the benefits of the game-based approach by comparing students' knowledge and skills before and after implementing this approach. In addition, some articles are interested in students' engagement and raising students' interest and motivation for the learning process by implementing a game-based approach. However, just a few articles refer to using this approach for measuring students' overall satisfaction with the whole experience (3 of 113).

### Distribution of published articles by implemented pedagogical strategy and used technology

Manual analyses of the included articles gave us insight into additional aspects of implementing a game-based approach in computer science. When we talk about the game-based approach, there are two main pedagogical strategies for implementation: students can learn by playing the game, and students can learn while creating the game. The distribution of those two approaches in the published articles indicates that learning by playing games is more frequently used than learning by creating games. Only 19 of 113 relevant articles refer to the implementation of a game-based approach, where students learn during the process of game design or are involved themselves in the creation of the game. In most of the articles, students just use the created game (previously created or designed for the purpose of the research) to develop their competencies on a given topic. Regarding the technology used for the creation of the games in the published articles, it can be noticed that most of the games are web-based (although they have a mobile version, too), and there are just a few articles concerning the use of the unplugged activities as a game-based approach for learning computer science.

### Distribution of published articles by covered computer science topic

Most of the articles concerning computer science topics covered during the implementation of the game-based approach refer to using to develop students' programming skills in object-oriented programming, followed by the articles concerning block-based programming and the development of computational thinking skills. The number of articles that utilize the game-based approach in all other computer science topics is significantly smaller (in total, 14 from 113 articles). Figure 7 contains more detailed information about this distribution.

## Discussion

### Types of educational games used for implementation of the game-based approach in computer science

Our research aims to provide information about the latest research trends concerning game-based learning in computer science education. Table 3 gives information about the implemented game, the type of the game, the computer science topic covered by the game, and the

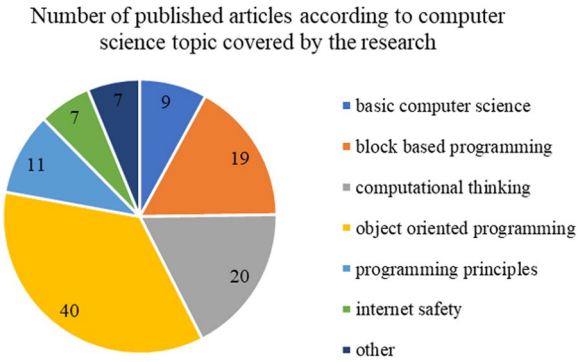


**Fig. 7** Distribution of the published articles according to the covered computer science topics

educational level, where the research concerning the game-based approach in computer science was carried out. The type of the game refers to the origin of the game creation, whether the game was already created and can be used or is created for the research by the author or by the students (they are learning during the game design process).

Detailed analysis of these relevant articles shows that different educational games are used to implement game-based learning in computer science, implementing different technologies for their design. Articles refer to using different platforms, environments or engines for creating games using different technology. In primary education, most implemented approaches include block-based environments, such as Blocky, Snap!, and Scratch. Those platforms give access to the already created game (De Carvallho et al., 2020; Sáiz Manzanares et al., 2020; Vourletsis & Politis, 2022) but also offer possibilities a game to be created by a teacher (Bevčič & Rugelj, 2020; Holenko Dlab & Hoic-Bozic, 2021; Wong & Jiang, 2018) or by the students during the learning process (Funke et al., 2017; Zeevaarders & Aivaloglouor, 2021). Even more, their use as a platform to code Arduino boards is presented in two of the articles (Sharma et al., 2019; Yongqiang et al., 2018). Block-based environments are used in the research in secondary education, too. For example, Araujo et al. (2018) measured students' motivation for learning block-based programming by involving students in creating games in Scratch. Schatten and Schatten (2020) involve students in creating different games using CodeCombat during the CodeWeek initiative to increase their interest in programming, and Chang and Tsai (2018) are implementing an approach for learning programming in pairs while coding Kinnect with Scratch.

However, in the research articles concerning secondary education, it can be noticed that some specified games are created by the researcher (or teacher) to develop some concrete computer science skills. In these cases, the articles focus on the evaluation of the effectiveness of the game as an approach. For example, the chatbot's serious game "PrivaCity" (Berger et al., 2019) is designed to raise students' privacy awareness, as a very important topic among teenagers.

Similarly, "Capture the flag" is a game designed for learning about network security in a vocational school (Prabawa et al., 2017). The effectiveness of using the educational game "Degraf" in a vocational high school as supplementary material for learning graphic design subjects is measured by Elmunsyah et al. (2021). Furthermore, Hananto and Panjaburee (2019) developed the semi-puzzle game "Key and Chest" to develop algorithm thinking skills and concluded that this digital game could lead to better achievement than if the physical game is used for the same purpose. The number of games developed at the university level on a specific topic by the researchers is even more significant. However, there is still no standardized game, and the games differ among themselves depending on the topic covered by the game and the country, where the game is implemented.

Only a few games are mentioned more than once in the list of relevant articles. The implementation of "Code defenders" to enable students to learn about software testing in a fun and competitive way is researched by Clegg et al. (2017) and Fraser et al. (2020). However, the studies continue each other, presenting improvements in the game. Different block-based programming languages and online platforms such as Scratch, Snap!, and Code Combat are mentioned in several articles, too. Implementation of a game-based approach during the assessment process through the creation of quizzes in Kahoot is presented by Abidin and Zaman (2017) and Videnovik et al. (2018). Finally, several articles refer to the use of Escape room as a popular game implemented in an educational context (Giang et al., 2020; López-Pernas et al., 2019, 2021; Seebauer et al., 2020; Towler et al., 2020). However, all these Escape room-style games are created on different platforms and cover different topics. Therefore, it can be concluded that no standardized type of game is implemented at a certain educational level or concerning a specific topic.

Further analyses were done concerning the type of the game, referring to the origin of the game: already created and just used for the research, created by the researcher for the purpose of the research or created by the students during the learning process. The distribution of the number of articles according to the type of the game in different educational levels is presented in Fig. 8.

Most of the articles describe the implementation of a game-based approach when the author creates the game to test the game's efficiency and make improvements

**Table 3** Analyzed articles concerning the implementation of game-based learning in computer science

| References | Educational level | Implemented game | Type of the game | Computer science topics covered by the game |
|---|---|---|---|---|
| Abdellatif et al. (2018) | University | Robocode | Already created | Object-oriented programming |
| Abidin & Zaman (2017) | University | Kahoot | Author | Object-oriented programming |
| Agalbato and Loiacono (2018) | University | Robo | Already created | Block-based programming |
| Agbo et al. (2021) | University | Online platform | Students | Computational thinking |
| Alatrista-Salas and Nunez-Del-Prado (2018) | University | CodeCombat | Already created | Object-oriented programming |
| Araujo et al. (2018) | Secondary | Scratch | Students | Block-based programming |
| Baek and Oh (2019) | Primary | Code Planet | Author | Object-oriented programming |
| Barriga & Besoaín (2020) | University | No specific game | Students | Programming principles |
| Berger et al. (2019) | Secondary | Privacy | Author | Internet safety |
| Bevcic and Rugelj (2020) | Primary | Snap! | Author | Block-based programming |
| Borna and Rad (2018) | University | Unity 3D Engine, Kahoot, Pulse | Author | Programming principles |
| Chang and Tsai (2018) | Secondary | Kinnect + Scratch | Students | Object-oriented programming |
| Clegg et al. (2017) | University | Code Defenders | Author | Other |
| Corda et al. (2019) | University | BashDungeon | Author | Basic computer science |
| Daungcharone et al. (2017) | University | PC game | Author | Object-oriented programming |
| De Carvalho et al. (2020) | Primary | Snap!, Run Marco, CodeCombat, Human Resource Machine, Light Bot, May's journey | Already created | Block-based programming |
| De Kereki and Adorjan (2018) | University | Kulami. Morelli, Pentago, FlipFlop, Quinamid | Already created | Computational thinking |
| De Troyer et al. (2019) | University | TrueBiters | Author | Basic computer science |
| Dočkalová Burská et al. (2021) | University | Training Analysis Tool | Author | Internet safety |
| Dos Santos et al. (2018) | University | Code Combat, Code Hunt | Already created | Object-oriented programming |
| Duch and Jaworski (2018) | University | Arduino-based educational Board | Students | Object-oriented programming |
| Eleftheriadis and Xinogalos (2020) | University | Office Madness | Author | Object-oriented programming |
| Elmunsyah et al. (2018) | Secondary | Mobile-based educational game | Author | Object-oriented programming |
| Elmunsyah et al. (2021) | Secondary | Degraff | Author | Other |
| Emembolu et al. (2019) | Primary | Gamefoot engine | Students | Block-based programming |
| Evripidou et al. (2021) | Primary | Bee-Bot robot | Students | Computational thinking |
| Fraser et al. (2020) | University | Code Defenders | Author | Other |
| Funke et al. (2017) | Primary | Scratch | Students | Computational thinking |
| Gaborik et al. (2019) | Secondary | Board Nanu game | Already created | Object-oriented programming |
| Garcia-Ruiz et al. (2021) | Primary | Micro:bit projects | Students | Object-oriented programming |
| Gardeli and Vosinakis (2019) | Primary | Request | Author | Computational thinking |
| Giang et al. (2020) | University | Escape room | Author | Object-oriented programming |
| Gossen et al. (2018) | University | Games with Cinco Adventure Game Tool | Students | Computational thinking |
| Groza et al. (2020) | University | MineFOL game | Author | Basic computer science |
| Gulec et al. (2019) | University | CONGO | Author | Object-oriented programming |
| Hananto and Panjaburee (2019) | Secondary | Key and Chest | Author | Computational thinking |
| Holanda et al. (2020) | Secondary | Kodu, MIT Inventor, Arduino, | Students | Object-oriented programming |
| Holenko Dlab and Hoic-Bozic (2021) | Primary | Snap! | Author | Block-based programming |
| Hong and Chu (2017) | University | Situated 3D game | Author | Object-oriented programming |
| Horst et al. (2019) | University | FunPlogs | Author | Programming principles |
| Huang et al. (2019) | Secondary | Set of board games | Author | Object-oriented programming |
| Huang et al. (2021) | University | pyMaze | Author | Object-oriented programming |
| Jagušt et al. (2018) | Primary | Unplugged activities | Already created | Computational thinking |
| Jovanov et al. (2017) | University | Unity 3D platform | Students | Other |
| Kanellopoulou et al. (2021) | Primary | Code | Already created | Block-based programming |

**Table 3** (continued)

| References | Educational level | Implemented game | Type of the game | Computer science topics covered by the game |
|---|---|---|---|---|
| Kannappan (2019) | University | La Petite Fee Cosmo | Author | Programming principles |
| Kantharaju et al. (2020) | University | Parallel | Already created | Object-oriented programming |
| Kazimoglu (2020) | University | Program Your Robot | Author | Computational thinking |
| Kintsakis and Rangoussi (2017) | Primary | Scratch | Author | Block-based programming |
| Klimová et al. (2021) | Primary | Minecraft | Students | Object-oriented programming |
| Kučera et al. (2020) | University | Interactive application in Unity | Author | Object-oriented programming |
| Kurniawati et al. (2018) | Primary | 2D Maze, 3D adventures | Author | Block-based programming |
| López-Fernández et al. (2021a, 2021b) | University | Flappy Bird | Author | Programming principles |
| López-Fernández et al. (2021a, 2021b) | University | LEGO® Serious Play | Students | Object-oriented programming |
| López-Pernas et al. (2019) | University | Escape Room | Author | Object-oriented programming |
| López-Pernas et al. (2021) | University | Escape room | Author | Object-oriented programming |
| Lotfi et al. (2019) | University | OOP SG | Already created | Object-oriented programming |
| Malizia et al. (2017) | University | TAPASPlay | Author | Computational thinking |
| Martins et al. (2019) | Secondary | Kahoot | Author | Other |
| Meftah et al. (2019) | University | Marco Run | Already created | Object-oriented programming |
| Miljanovic and Bradbury (2020) | University | GidgetML | Author | Programming principles |
| Min et al. (2020) | Primary | Engage | Author | Block-based programming |
| Montes et al. (2021) | Secondary | DFD-C | Author | Object-oriented programming |
| Mosquera et al. (2020) | Primary | sCool platform | Author | Object-oriented programming |
| Nche et al. (2019) | Primary | CodeTracesure | Author | Computational thinking |
| Nche et al. (2020) | primary | Codetracesure | Author | Computational thinking |
| Noval et al. (2019) | University | Robocode, Battlebot | Author | Basic computer science |
| Paiva et al. (2020) | University | Asura environment | Students | Object-oriented programming |
| Pila et al. (2019) | Primary | Daisy the Dinosaur, Kodable | Already created | Block-based programming |
| Popović et al. (2017) | Primary | Angry Birds | Already created | Computational thinking |
| Prabawa et al. (2017) | Secondary | Capture the flag | Already created | Internet safety |
| Priyadarshini et al. (2020) | University | The game-based learning mobile app | Author | Object-oriented programming |
| Rajeev and Sharma (2018) | University | Vizard platform | Author | Object-oriented programming |
| Riera et al. (2019) | University | HOME I/O, Scratch 2.0 | Already created | Basic computer science |
| Roussou and Rangoussi (2020) | Primary | Robot Code & Go Robot Mouse | Students | Computational thinking |
| Rozali and Zaid (2017) | University | Mobile game | Author | Other |
| Sáiz Manzanares et al. (2020) | Primary | Blockly Games | Already created | Block-based programming |
| Schatten and Schatten (2020) | Secondary | CodeCombat | Students | Block-based programming |
| Seebauer et al. (2020) | University | Escape Room | Author | Basic computer science |
| Seralidou and Douligeris (2020) | Primary | Kodu Game Lab, Light Bot, Kahoot, Scratch | Students | Programming principles |
| Sharaf et al. (2020) | Primary | Treasure hunt style game | Author | Object-oriented programming |
| Sharma et al. (2019) | Primary | Scratch + Arduino | Students | Block-based programming |
| Shim et al. (2017) | Primary | Robot game | Students | Object-oriented programming |
| Siakavaras et al. (2018) | University | Platforms for LBG—Tale Blazer, ARIS, 7scenes, Wherigo | Author | Internet Safety |
| Silva et al. (2020) | University | The Turing Project | Author | Basic computer science |
| Simões Gomes et al. (2018) | Primary | Code Baymax; LightBot | Already created | Block-based programming |
| Sookhanaphibarn and Choensawat (2020) | University | Laptop Security, Social Network, Cyber Defender, Quiz Tank, Cyber Runner | Author | Internet safety |
| Stigall and Sharma (2017) | University | Second Life | Author | Object-oriented programming |
| Tabuti et al. (2020) | University | Online migration of traditional game | Students | programming principles |
| Tacouri and Nagowah (2021) | University | Code Saga | Author | Object-oriented programming |

**Table 3** (continued)

| References | Educational level | Implemented game | Type of the game | Computer science topics covered by the game |
|---|---|---|---|---|
| Taylor et al. (2019) | Secondary | IntelliBlox toolkit | Students | Block-based programming |
| Towler et al. (2020) | University | Logic Descent—Escape room | Author | Basic computer science |
| Tretinjak (2019) | Secondary | Unplugged games | Author | Computational thinking |
| Vahldick et al. (2020) | University | NoBug's, SnackBar | Author | Computational thinking |
| Valle et al. (2017) | University | Testing Game | Author | Other |
| Venkatesh et al. (2021) | Primary | Unplugged activities | Author | Computational thinking |
| Ventura et al. (2017) | University | Video games using Unity3D | Students | Object-oriented programming |
| Videnovik et al. (2018) | Primary | Kahoot | Author | Basic computer science |
| Visoottiviseth et al. (2018) | University | Lord of Secure | Author | Internet safety |
| Voštinár (2021) | Primary | MakeCode Arcade | Author | Block-based programming |
| Vourletsis and Politis (2022) | Primary | Games in Scratch | Already created | Computational thinking |
| Wong and Jiang (2018) | Primary | Games in Scratch | Author | Computational thinking |
| Wong and Yatim (2018) | University | Greenfoot, Darwin CodeCombat | Author | Object-oriented programming |
| Wong et al. (2017) | University | The Odyssey of Phoenix | Author | Object-oriented programming |
| Workman et al. (2021) | University | Secure Code Warrior | Already created | Internet safety |
| Xian (2021) | University | Sandbox game LE | Author | Object-oriented programming |
| Yallihep and Kutlu (2020) | Primary | Lightbot | Already created | Object-oriented programming |
| Yokoyama et al. (2020) | University | RPA | Author | Object-oriented programming |
| Yongqiang et al. (2018) | Primary | Scratch + Arduino | Students | Block-based programming |
| Yücel and Rızvanoğlu (2019) | Primary | Code Combat | Already created | Block-based programming |
| Zapata-Cáceres & Martín-Barroso (2021) | Primary | Visual environment Blue Ant Code | Author | Computational thinking |
| Zeevaarders and Aivaloglou (2021) | Primary | Scratch | Students | Object-oriented programming |
| Zhao et al. (2021) | University | Three games on NEWTELP platform | Author | Object-oriented programming |

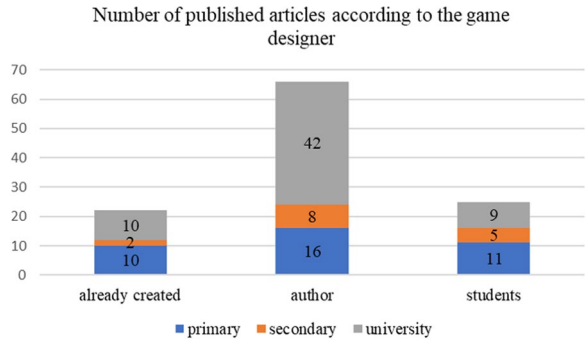


**Fig. 8** Distribution of the published articles according to the game designer in different educational levels

based on the feedback received by the students. The number of games created by the author is the biggest at the university level, and the most balanced distribution of different kinds of games (created by the author, students or already created) is present in primary education. Interestingly, the most significant number of articles that concern using games created by students is in primary education. It shows that students in primary education have been the most involved in the process of game design, although they are young and have less knowledge and skills than students at other educational levels. This could be result of the fact that the articles that refer to primary education present a game's design only in a block-based environment and using basic programming concepts. However, research articles do not refer to a standardized methodology of a framework for the creation of a game, and each game is designed individually depending on the used technology, topic and educational level.

### Pedagogical strategies for implementation of the game-based approach in computer science

A detailed analysis of the pedagogical strategies for implementing a game-based approach shows that most relevant articles use games as a tool for learning the content. This trend continues in the recent period as well (Kaldarova et al., 2023). Hence, students play the game (already created or created by an author) to gather knowledge or develop their skills. Detail distribution of the research articles regarding pedagogical strategies for implementing a game-based approach is presented in

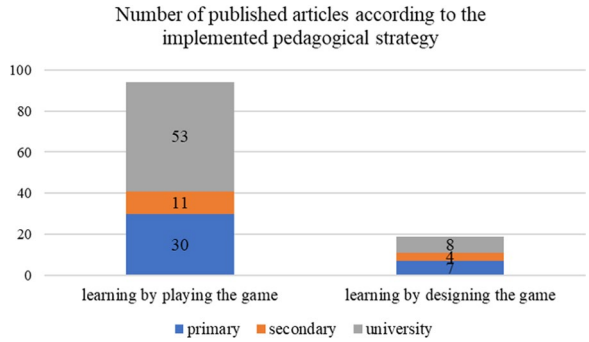


**Fig. 9** Distribution of the published articles according to the implemented pedagogical strategy

mainly taught by a game-based approach at university is object-oriented programming. The situation is similar in secondary schools. Game-based approach is suitable classroom strategy for fostering higher order thinking skills, such as problem solving, group collaboration, and critical thinking, that are developed during learning object-oriented programming, which is consistent with previous research conducted by Chen et al. (2021).

This can be expected, because the topic is complex for the students, and teachers must find different approaches and strategies to make it more understandable. In addition, in those educational levels, there is a distribution of the articles in different mentioned computer science topics (although it is not equally distributed).

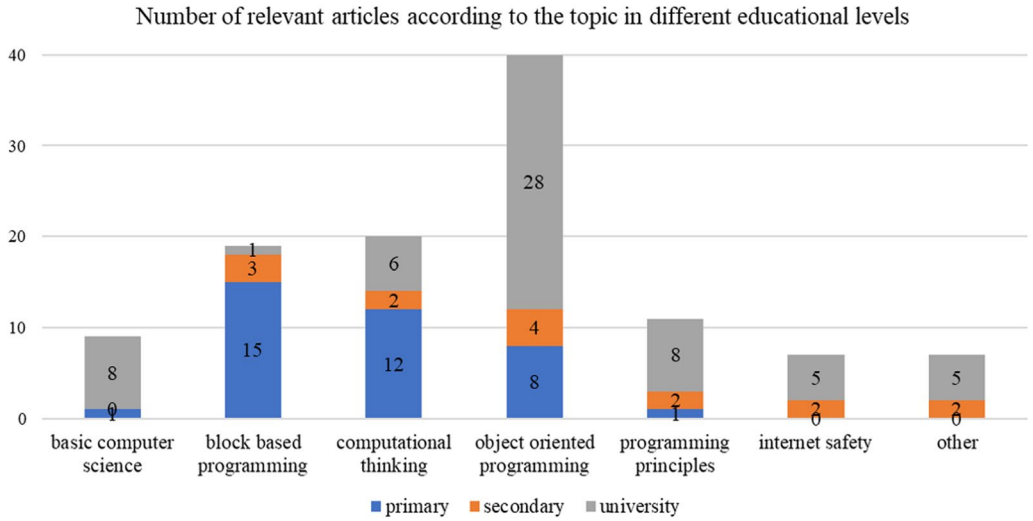


**Fig. 10** Distribution of the published articles concerning the covered computer science topics

Fig. 9 and more detailed data can be found in Table 3. Some articles explain how students learn during the process of the creation of a game. Those are different games at different educational levels, but they all concern the process of designing a game on some platform that will develop their programming skills. Unfortunately, no article describes the process of developing students' knowledge and skills on different computer science topics than programming while designing a game. It is a critical gap that should be considered as a topic in future research: to see whether students can learn about other computer science topics during the game creation process (while they develop their programming skills).

### Computer science topics covered by game-based approach in computer science

Figure 10 gives insight into the distribution of the relevant articles concerning the computer science topic covered by the game-based approach. The topic that is

However, if we analyze the topics covered by the game-based approach in primary education, it can be noticed that this approach is implemented in several topics only, mainly connected with the development of students' computational thinking skills and fundaments of programming languages (see Table 3 for detailed overview). This trend continues in the recent years (Cheng et al., 2023; Mozelius & Humble, 2023).

Students in primary education mostly learn block-based programming languages, so it is expected that this will be the most frequent topic covered by the game-based approach. However, some articles also refer to object-oriented programming taught in upper grades. The interesting finding is that there are no articles about using educational games to learn other computer science topics, such as hardware, some applications, networks, and cybersecurity, in primary education, as there are in other educational levels. For example, there are

two articles that elaborate on learning about internet safety using games in secondary education (Berger et al., 2019; Prabawa et al., 2017), and no article on game-based learning for internet safety in primary education. This lack of research articles concerning using the game-based approach for learning other topics in computer science in primary education can help identify potential future research topics.

#### Potential research topics concerning the game-based approach in computer science

While the lack of research articles concerning using the game-based approach for learning other topics in computer science in primary education is a good starting point for identifying potential future research topics, it is important to consider it in combination with practical constraints such are lack of knowledge, access to technology or teacher training on a specific subject. In that context, "Identifying the challenges, opportunities and solutions for integrating game-based learning methods in primary schools for specific computer science topics" can be a future research topic. It should be noted, that although some articles on specific topics can be found in the recent literature (Alam, 2022), there is a huge pool of topics, such are internet safety and digital citizenship that can be explored in this context.

There is an evident lack of articles on the use of game-based learning in primary and secondary schools. The findings in the existing literature that elaborate on how specific game design elements influence the learning process are minimal (Baek & Oh, 2019; Dos Santos et al., 2019; Emembolu et al., 2019; Kanellopoulou et al., 2021). These findings, combined with the finding of a limited number of articles that use existing games in the process of learning, define the potential future research topic "Assessing the role of game design elements in enhancing engagement and understanding of computer science concepts among primary and/or secondary school students". This research topic can use conceptual framework that investigates how specific elements of game design can contribute to increased engagement and improved understanding of computer science concepts in primary or/and education.

This research topic includes various specific research questions and theoretical frameworks. One possible set of research questions can investigate the specific elements of game design that can be incorporated into educational games or learning activities to enhance the learning experience. These elements may include interactive interfaces, engaging narratives, immersive environments, feedback mechanisms, competition or collaboration features, levels of difficulty, rewards, and progression systems. Different theories such are social cognitive theory (Lim et al., 2020) and self-determination theory (Ryan et al., 2006) can be used to better understand the motivational factors of different game design elements (interactivity, challenges, and rewards), and how they influence student engagement and sustain student interest and active participation in computer science learning.

All mentioned research questions can be investigated by conducting experiments, surveys, observations, or interviews to gather quantitative and qualitative data on student experiences and perceptions. Combined with data from learning outcomes, these potential findings can provide the information about overall effectiveness of using the elements of a game-based approach to learning computer science in primary schools.

#### Limitations

This scoping review focuses on the articles in four digital libraries, potentially leaving a significant number of articles out of the analyzing process.

Using the NLP toolkit automates searching for relevant articles. Undoubtedly, a human reader might better understand the context and better assess the relevance of an article and potentially include some articles that NLP toolkit classified as irrelevant. In addition, after the initial selection by NLP toolkit, we performed the quality assessment of the identified articles, for each of the research questions. In that way, we ensured that only relevant articles are included in the study, but it might happen that, due to the phase of selection some relevant articles were omitted from the study.

Detailed meta-analyses within the selected group of articles concerning a particular research feature can further contribute to the existing body of knowledge. Similar analyses exist, but not on learning computer science (Gui et al., 2023). For example, in our manuscript, we did not consider the size of the student population, existence of the control group of students, or replicability of the studies.

## Conclusion

This scoping review discusses implementation of game-based approach in computer science by analyzing research articles in four digital libraries published between 2017 and 2021. In total, 113 research articles were analyzed concerning the educational level, where the game-based approach is implemented, the type of the game, covered computer science topic, pedagogical strategy and purpose of the implementation. The results show that the number of research articles is increasing through the years, confirming the importance of implementing a game-based approach in computer science. Most of these articles refer to the research in just one country, in the local context, making it difficult to generalize the

research outcomes and conclusions on the international level.

The article presents various games using various technologies concerning several computer science topics. However, there is no standardized game or methodology that can be used for designing an educational game. Implemented game in each of the researched articles depends on the educational level, covered topic and game type. From our findings, it is evident that most articles refer to the implementation of the game-based approach, where students gather the necessary knowledge and skills while playing a game. Just a few of them incorporate the process of learning by designing educational games, and this learning is connected to developing computational thinking or programming skills.

Potential future research might be focused on identifying the challenges, opportunities, and solutions for integrating game-based learning methods for a specific computer science topic. Example topics might be internet safety and digital citizenship.

The lack of research articles on game-based learning in primary and secondary schools, along with limited findings on the influence of game design elements, highlights the need to assess how different elements enhance engagement and understanding of computer science concepts.

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**Author contributions**
VT and AMB had the idea for the article. TV defined the methodological steps. MV and AMB performed the literature search and data analyses. Data analyses were supported by VT and LK. MV drafted the article, while TV critically revised the work.

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**Availability of data and materials**
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## Declarations

**Competing interests**
The authors declare that they have no competing interests.

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