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# Trends and Developments in Gamification for Science Education: A Bibliometric Review from 2019 to 2023

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**Abstract:** This study aims to identify and analyze research trends in gamification focusing on science education and explore opportunities for further development. Using the Systematic Literature Review (SLR) method, a total of 126 relevant publications were identified from the Publish or Perish database indexed by Scopus, with 43 documents from the 2019–2023 period selected and analyzed based on inclusion criteria. These criteria include articles discussing gamification in science education, English-language articles, open-access publications, and Scopus-indexed articles. The literature review process followed PRISMA guidelines to ensure the quality of results, and data were analyzed using bibliometric methods with the assistance of VOSviewer 1.6.20 software. The results indicate significant fluctuations in the number of publications and citations year by year, reflecting the dynamics of research activity. Most publications originate from Spain, the United States, and Malaysia, with quantitative methods being the most widely used approach (51%). The main themes explored include student engagement, motivation, and conceptual understanding, particularly in STEM subjects. Collaborative networks highlight the importance of diverse perspectives in advancing gamification research. Density analysis reveals that the long-term impact and scalability of gamification in educational science still hold substantial potential for exploration. Therefore, further studies are urgently needed to optimize the role of gamification and maximize its benefits in the learning process.

**Keywords**: Bibliometric analysis; Gamification; PRISMA; Science education; SLR

## Introduction

The use of gamification in science education has attracted growing interest as a creative approach to improve student engagement and learning results. By integrating game elements into non-game settings, gamification has demonstrated its effectiveness in increasing motivation and aiding the comprehension of complex scientific concepts (Hursen & Bas, 2019; Jaramillo-Mediavilla et al., 2024). Research by Alahmari et al. (2023) and Kalogiannakis et al. (2021) indicates that gamification elements not only heighten students' enthusiasm for learning science but, more importantly, improve the quality of activities produced. Additionally, studies by Mekler et al. (2017) and Xu et al., (2021) reveal that gamification fosters intrinsic motivation by providing immediate feedback and a sense of achievement. As digital technologies evolve, gamification has become increasingly significant, particularly in science education, which often presents abstract and challenging concepts to students.

The adoption of gamification in science education can be attributed to the growing recognition that traditional teaching methods are not always sufficient to foster deep engagement and intrinsic motivation among students. Gamification offers an alternative approach by

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creating immersive learning environments where students can actively participate, experiment, and collaborate, thereby enhancing their learning experiences (Hayes et al., 2023; Lee et al., 2023). For instance, a study by Yang & Oh (2022) demonstrated that a gamified neonatal resuscitation program using immersive virtual reality effectively improved knowledge of neonatal resuscitation, problem-solving skills, confidence, and learning motivation. Furthermore, the rapid advancement of technology, including interactive simulations, mobile applications, and online platforms, has facilitated the implementation of game-based learning strategies across various educational settings (Areed et al., 2021; Riyandi et al., 2023). Research by Jiang & Boulom (2024) also highlights that the integration of virtual laboratories and gamified content positively impacts students' conceptual understanding and motivation to learn STEM subjects.

Bibliometric research on the application of gamification in learning has generally been documented since 2019. However, a review of the existing literature reveals that bibliometric studies specifically focused on the use of gamification in science education have been limited over the past five years. Bibliometric analysis is a quantitative approach that utilizes mathematical and statistical techniques to assess the relationships and influence of publications, authors, institutions, and countries within a particular research domain (Aria & Cuccurullo, 2017; Fu et al., 2023; Shabira et al., 2024). This approach offers a comprehensive analysis of scientific output, highlights research trends over time, and identifies the leading authors and institutions (Irwanto et al., 2023). In a previous bibliometric study, López-Belmonte et al. (2020) examined the relevance and evolution of the concepts of "gamification" and "learning" in scientific literature indexed in the Web of Science (WoS), analyzing 1,230 publications from 2011 to 2019. They successfully mapped the research landscape of gamification in learning, highlighting the need for comprehensive studies that consolidate findings across various disciplines. This study seeks to present an overview of recent research and propose new directions in the field of gamification, particularly within science education. Additionally, the findings aim to serve as a foundation for future researchers exploring this area.

Earlier bibliometric studies have provided insights into the use of gamification in education, significantly enhancing the understanding of trends within this field. With the increasing number of empirical studies on gamification applications, a comprehensive synthesis of research dynamics and patterns has become highly necessary. This systematic bibliometric review aims to comprehensively examine publication trends and the progression of gamification research in education, with a specific focus on science education. The study explores various dimensions, including annual publication output, commonly used keywords, highly cited documents, and the most prolific authors, journals, and countries. The findings from this review are expected to complement the existing literature and provide insights into gamification patterns within the context of science education.

In this review, the authors conduct a comprehensive analysis of trends and developments in gamification within science education from 2019 to 2023. Bibliometric analysis is an effective tool for identifying patterns in academic publications, offering a clear picture of the growth and impact of this research area (Ellegaard & Wallin, 2015; Passas, 2024). VOSviewer was utilized to visualize data and identify the intellectual structure and trends in the literature (Shabira et al., 2024; Yan & Zhiping, 2023), enabling researchers to observe relationships between various elements in gamification research. This study aims to provide insights into the evolution of gamification research and its applications in science education, focusing on the methodologies employed and emerging trends. The findings are expected to contribute to the advancement of knowledge on gamification and offer valuable insights for educators, researchers, and policymakers regarding the effectiveness of game-based learning strategies. Furthermore, this article discusses the practical implications of these findings, offers recommendations for integrating gamification into science curricula, and proposes future research directions. The research questions guiding the current study are as follows:

RQ1: What are the key publication trends in gamification research for science education from 2019 to 2023?

RQ2: Who are the most productive authors, journals, and countries in gamification research for science education?

RQ3: What is the intellectual structure and collaboration pattern in the gamification literature for science education?

RQ4: What methodologies are used in gamification research for science education?

RQ5: What are the five most frequently cited articles in gamification research, and how have they impacted the improvement of students' learning outcomes?

## Method

*Search Design*

This study employed the Systematic Literature Review (SLR) method to identify, review, and analyze

research trends in gamification within science education (Fitri et al., 2023; Wahdah et al., 2023), covering the period from 2019 to 2023. The article search and selection process adhered to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) to ensure data quality and accuracy (Nurhayati et al., 2023). PRISMA enabled the study to follow systematic stages, including identification, screening, and eligibility assessment of articles relevant to the research topic (Mustika & Hasby, 2022). Data for this study were collected from the Publish or Perish database indexed in Scopus, a trusted source for scientific publications in education (Yokhebed et al., 2023). Keywords such as "Gamification" and "Science Education" were used to search for relevant articles. A total of 43 articles were selected out of 126 identified, following tabulation using Microsoft Excel. These articles encompassed publications related to gamification in science education from various countries. A rigorous selection process was undertaken based on titles, abstracts, keywords, and content to maintain relevance to the research objectives and avoid bias (Husna et al., 2023; Khoeriah et al., 2022).

Bibliometric analysis was applied to map the scientific contributions related to gamification in science education, focusing on authors, institutions, and journals significantly contributing to this topic (Stürmer et al., 2018). This analysis also helped identify collaboration patterns among researchers and thematic distributions in the literature (Nisa et al., 2023; Paju et al., 2022). The VOSviewer software (version 1.6.20) was used to visualize collaboration networks and key topics emerging in the research (Padmalia, 2023). VOSviewer facilitated mapping the relationships between keywords, authors, and publications, providing deeper insights into the research dynamics and developments in gamification in science education (Salsabiila & Yuadi, 2023; Wicaksono et al., 2023) over the past five years. The bibliometric analysis results were further processed using software such as Mendeley for reference management and Microsoft Excel for quantitative data processing. With this systematic approach, the study aims to present a comprehensive representation of the scientific contributions to the application of gamification in science education and provide recommendations for future research directions.

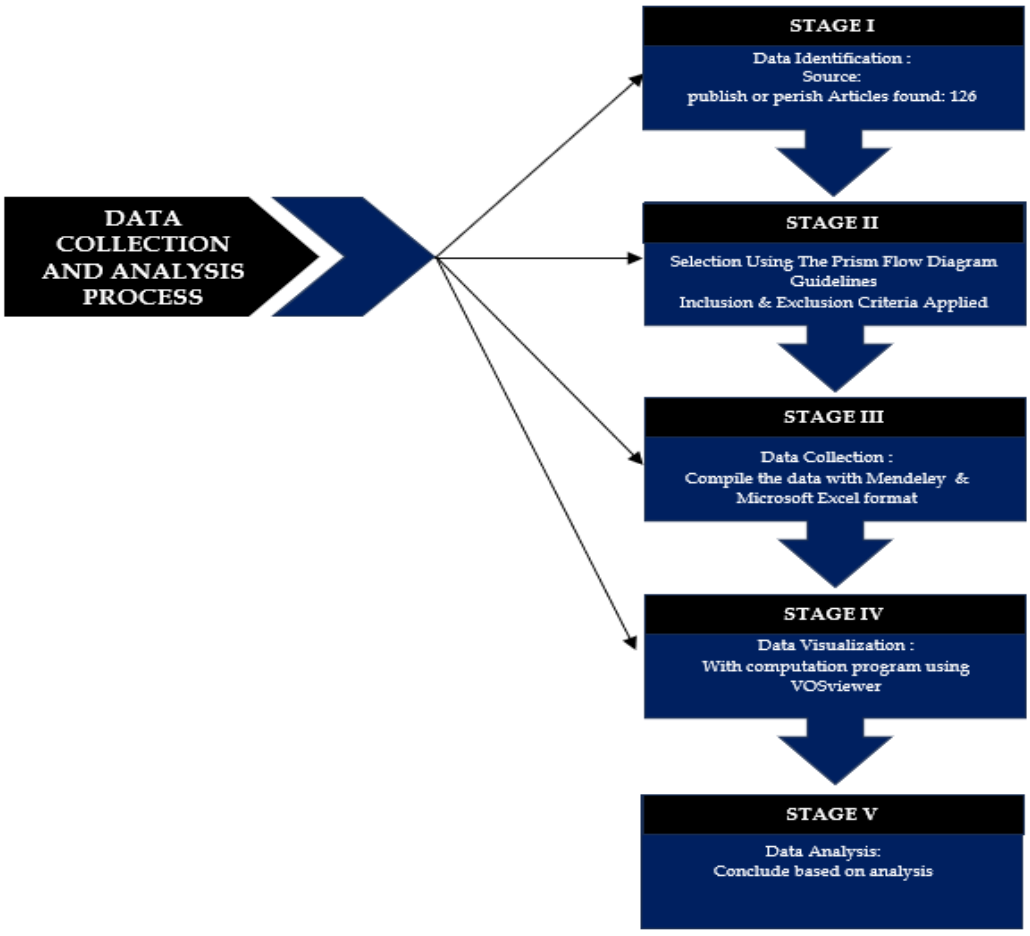



**Figure 1.** Data collection and analysis process

*Search Strategy*

As an initial step in the literature review, the strategy for searching the literature relied on online databases. The researchers used Scopus-indexed articles, with data retrieved from Scopus using Publish or Perish to search for and gather relevant sources. This database was selected due to its high quality, broad acceptance, and comprehensive digital library, which is user-friendly for retrieving information on education and technology online. The details are presented in Table 1.

**Table 1.** Database search strategy

| Filter | Description |
|---|---|
| Year | 2019-2023 |
| Subject area | Social science |
| Search string | "Gamification" OR "Engagement strategies" "Playful design" AND "Education Science |
| Source type | Journal |
| Language | Inggris |
| Document type | Article (Open access) |
| Rank type | Scopus Indexed |

The search from this database resulted in 126 articles sourced from Publish or Perish indexed in Scopus. Subsequently, all articles were identified and analyzed for their relevance to the research questions and objectives. This study employed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, which included setting selection criteria, extraction methods, removing duplicate articles across databases, and selecting studies based on title, abstract, and keywords to minimize researcher bias and errors (Donthu et al., 2021).

*Data Selection Criteria*

At this stage, strict literature selection criteria were applied to obtain documents that matched the specified keywords. Kholid et al. (2023) explained that the criteria used in document selection involved two categories: inclusion and exclusion. These criteria, as outlined in Table 2 below, were implemented to ensure the relevance and quality of the selected documents.

**Table 2.** Inclusion and exclusion criteria

| Criteria | Inclusion | Exluclusion |
|---|---|---|
| Title and Content | Related to gamification in science education | Titles that are not relevant |
| Publication Year | Publications from 2019 to 2023 | Publications outside the specified range |
| Type of Publication | Journal articles only | Reviews, editorials, and non-empirical studies |
| Language | English | Other languages |
| Field of study | Education | Other fields |
| Accessibility | Full-text or open-access articles | Articles requiring payment |
| Journal Indexing | Only Scopus-indexed articles | Others |

*Data Selection Process*

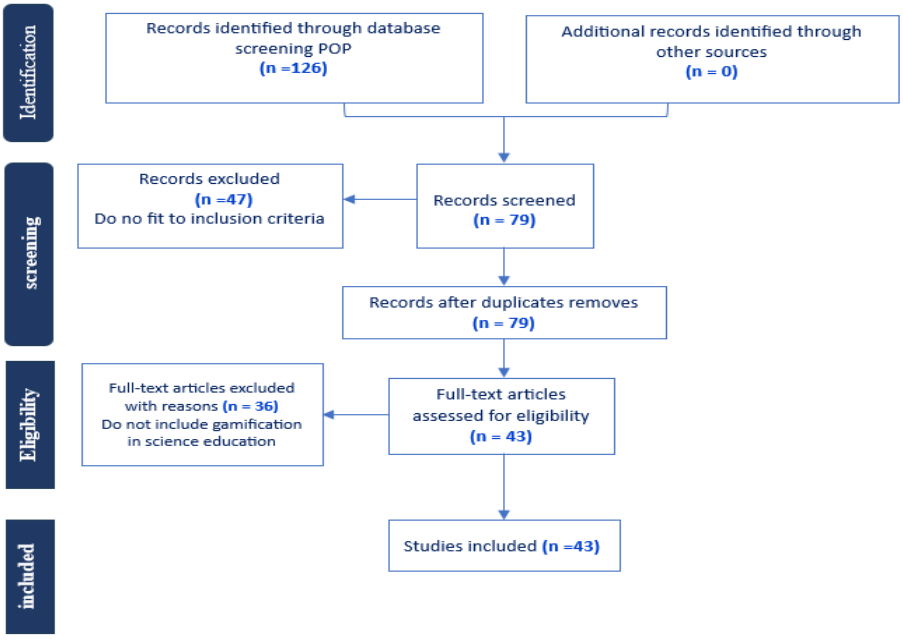



**Figure 2.** PRISMA review process

The data selection process is a critical element in literature reviews to ensure the validity and reliability of the research (Yang et al., 2021). To maintain data integrity and avoid potential bias, the primary focus was on identifying topics aligned with the research and seeking input from an independent expert panel. As noted by Schmitt et al. (2023), any discrepancies identified were resolved through in-depth discussions. At this stage, 126 articles were identified and thoroughly analyzed to gather information relevant to the research questions and objectives. The abstraction and data analysis process used in this study was based on a modified PRISMA protocol, as illustrated in Figure 1.

Using the predetermined keywords, 126 articles were identified from the Scopus-indexed Publish or Perish database. At the Identification stage, 126 documents were collected from the PoP database, while no additional documents were identified from other sources. During the Screening stage, 79 documents were screened, and 47 documents were eliminated for not meeting the established inclusion criteria. Next, at the Eligibility stage, 79 documents were further examined, and no duplicate data was found. Of the 79 articles assessed for eligibility, 36 were excluded due to irrelevance, particularly because they were not related to the topic of gamification in science education. Finally, 43 articles met the inclusion criteria and were included in the analysis for this study.

*Data Analysis*

All collected articles that met the research criteria were exported in RIS and CSV formats. The RIS format data were imported into Mendeley to verify and correct the necessary metadata. Subsequently, the data were computationally mapped using VOSviewer software. Meanwhile, the CSV data were tabulated in Microsoft Excel to facilitate the analysis of trends, gaps, and potential areas for further development.

Factors considered in the analysis included annual publication trends, citations, author productivity, country productivity, and commonly used research methods. The results of the analysis were used to identify thematic evolution and current research trends on the topic of gamification in science education. The final step of this study was to identify research gaps and propose future research directions regarding gamification in science education.

## Result and Discussion

In recent years, gamified learning in science education has garnered significant attention across various educational fields, particularly within science education. This study aims to analyze and explore publication trends, citations, journal contributions, visualize research trends, and identify gaps and potential areas for further development in advancing gamified learning in science education across different countries. The graph below illustrates the research trends on gamification in science education from 2019 to 2023.

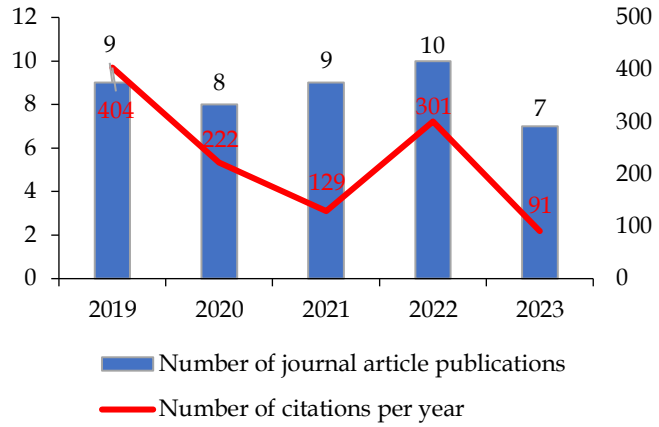



**Figure 3.** Trends in publications and citations

The figure illustrates the trends in publications and citations on gamification in science education from 2019 to 2023. The clustered column chart depicts the annual number of journal article publications, totaling 43 articles over the analyzed period. The graph highlights two primary trends: the number of journal article publications and the number of citations per year. Regarding journal article publications, the trend demonstrates significant fluctuations from year to year. There was a sharp decline from 2019 to 2020, followed by a notable increase in 2022, and another decline in 2023. These substantial variations indicate a lack of stability in the number of publications over the years. Similarly, the citation trend also shows fluctuations, albeit with a more consistent pattern of decline compared to the publication trend. However, the significant year-to-year decreases in citation counts reflect an overall lack of stability in this area as well.

In conclusion, the graph reveals that neither the number of journal article publications nor the number of citations per year exhibits stability. The significant fluctuations in both trends suggest complex dynamics in research activities, likely influenced by various internal and external factors.

Table 3 presents authors with the highest citation counts in gamification research within science education. Frequently cited authors, such as Felszeghy et al. (2019), with 120 citations, discussed the use of online game-based platforms, particularly Kahoot, to enhance student performance and engagement in teaching histology for medical and dental students. This

work is considered highly influential in the field. Their research is recognized as relevant, innovative, and significantly contributing to the advancement of knowledge on gamification in science education.

**Table 3.** Number of citations for the most cited publications

| Author | Scopus citation |
|---|---|
| Szabolcs Felszeghy, Sanna Pasonen-Seppänen, Ali Koskela, Petteri Nieminen, Kai Härkönen, Kaisa M. A. Paldanius, Sami Gabbouj, Kirsi Ketola, Mikko Hiltunen, Mikael Lundin, Tommi Haapaniemi, Erkko Sointu, Eric B. Bauman, Gregory E. Gilbert, David Morton and Anitta Mahonen | 120 |
| Cigdem Hursen, Cizem Bas | 98 |
| Alkinoos-Ioannis Zourmpakis, Stamatios Papadakis and Michail Kalogiannakis | 69 |
| Jenny Díaz-Ramírez | 68 |
| Dolores López Carrillo, Amelia Calonge García, Teresa Rodríguez Laguna, Germán Ros Magán and José Alberto Lebrón Moreno | 53 |

Among the 43 analyzed articles, involving 152 authors, collaboration emerged as a key characteristic. Nearly all entries in the table reflect joint efforts among multiple authors, enabling the integration of diverse perspectives and expertise, which leads to more comprehensive and high-quality research. As emphasized by Didham & Ofei-Manu (2020), such collaboration is crucial for developing and implementing effective gamification strategies in science education. The outcomes of these collaborations have facilitated broader adoption of gamification approaches and have had a significant impact.

Other authors, such as Zourmpakis, Papadakis, and Kalogiannakis, as well as Díaz-Ramírez, have also played vital roles in advancing gamification in science education across various countries. Their collective contributions highlight the importance of international collaboration in promoting gamification as an effective tool in education.

**Table 4.** Journals with the highest contributions

| Journal | Number |
|---|---|
| Education sciences | 5 |
| International Journal of Emerging Technologies in Learning | 4 |
| IEEE Transactions on Visualization and Computer Graphics | 3 |

This table highlights the journals that have made the most significant contributions to publications related to gamification in science education during the period 2019–2023. The three leading journals with the highest contributions are Education Sciences, International Journal of Emerging Technologies in Learning, and IEEE Transactions on Visualization and Computer Graphics. Table 4 highlights the journals with the highest contributions. Education Sciences, with 5 publications, focuses on science education, while the International Journal of Emerging Technologies in Learning and IEEE Transactions on Visualization and Computer Graphics, each with 4 publications, primarily focus on technology. Publications in these journals reflect close collaboration among researchers from diverse backgrounds, playing a crucial role in the development and dissemination of gamification research in science education. The study also emphasizes that synergy among researchers is a key factor in the success of gamification programs in science education (Zamora-Polo et al., 2019).

21 countries have published articles on gamification in science education in the Scopus database, highlighting the global reach and interdisciplinary nature of this field.

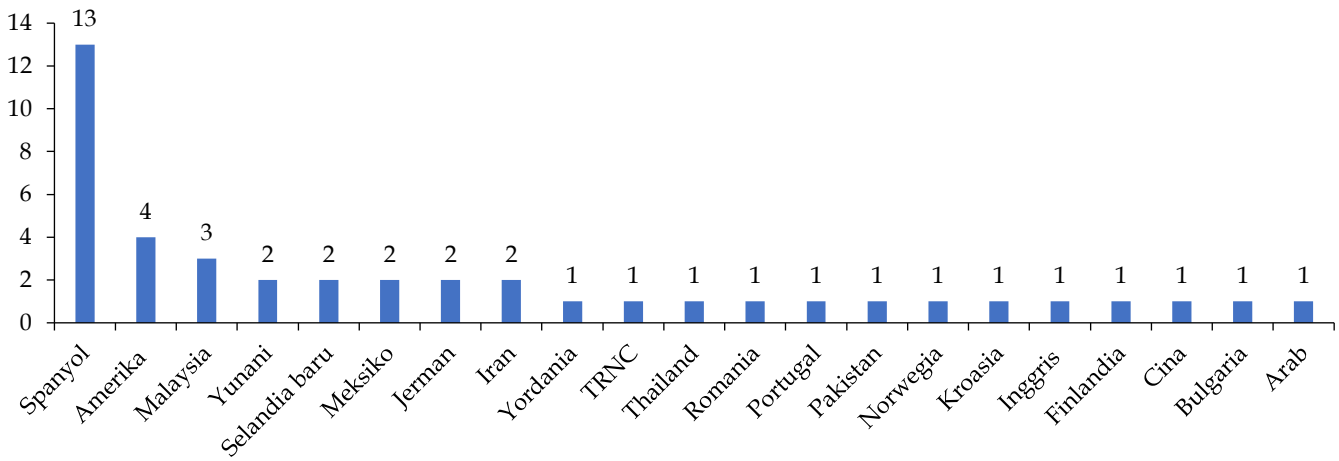



**Figure 4.** Countries and Number of Publications

Figure 4 displays the distribution of articles related to gamification in science education, based on data from the Scopus database. A total of 21 countries contributed to publications in this field. Spain stands out as the country with the highest number of publications, totaling 13 articles. One of the prominent studies from Spain, conducted by Manzano-León et al. (2023), examined the effects of an educational gamification program on the motivation, engagement, and academic flow of high school students from socially disadvantaged communities. This research aimed to enhance student motivation and engagement in learning science subjects, such as Physics and Chemistry, through interactive and enjoyable gamification-based learning strategies. The United States ranks second with 4 articles, followed by Malaysia with 3 articles. Other countries, including Mexico, Germany, Greece, Iran, New Zealand, Portugal, Romania, the Turkish Republic of Northern Cyprus (TRNC), Croatia, China, Pakistan, Jordan, Norway, Saudi Arabia, Finland, the United Kingdom, Bulgaria, and Thailand, each contributed one article. Collectively, these 18 countries accounted for 18 of the 43 articles analyzed.

This distribution reflects a global trend highlighting the increasing focus on integrating gamification into science education across different nations. Spain, as the leader in the number of publications, has made significant contributions to promoting research and applications of gamification in science education. On the other hand, contributions from various countries suggest potential for greater cross-country collaboration, which could accelerate the adoption and dissemination of gamification-based learning methods worldwide.

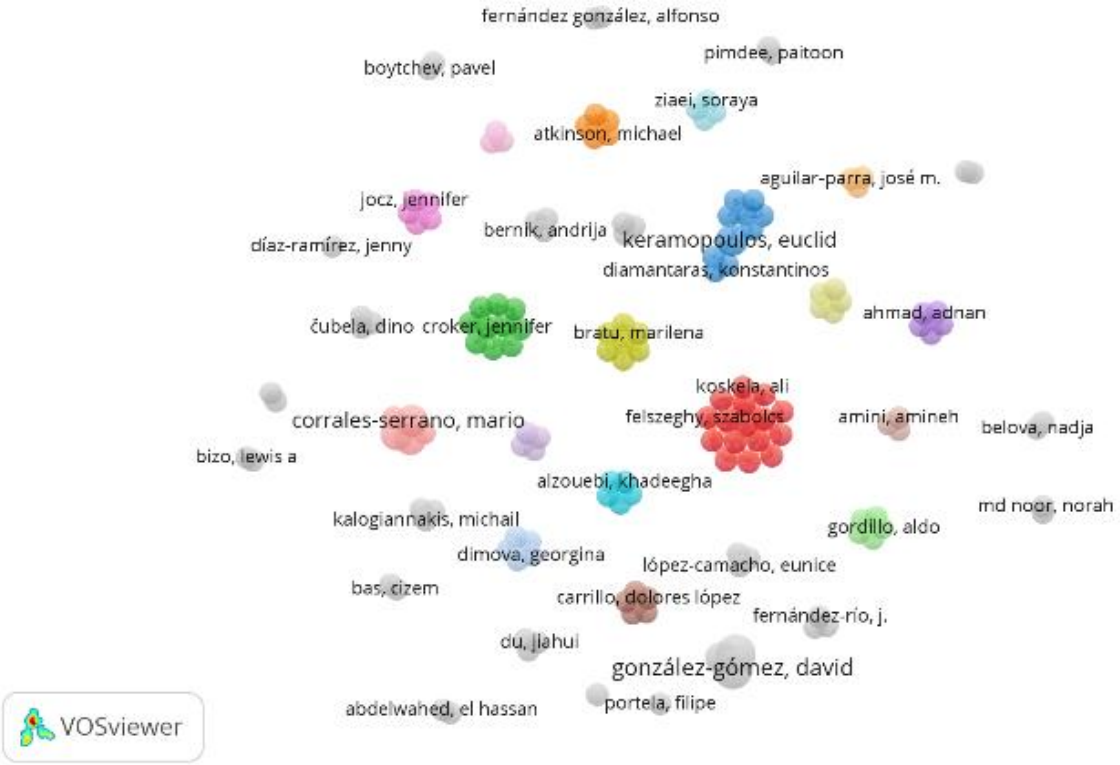



**Figure 5.** Visualization of author collaboration

Figure 5 illustrates the collaboration network among authors in research on Gamification for Science Education level over the past five years. This visualization was generated using VOSviewer and includes 152 researchers with 120 co-authorship links. Nodes (connection points) of the same color represent groups of authors who frequently collaborate, forming distinct collaborative clusters. These collaborations reflect common academic research patterns, where authors with similar research interests work together, creating focused research groups on specific topics (Alka et al., 2023). Each cluster represents a particular research topic, with certain authors at the center of the cluster. Notable contributors include Enrique Sánchez Rivas, Julio Ruiz-Palmero, and José Sánchez-Rodríguez, who play significant roles in the collaboration network. Their research focuses on the topic of "Gamification and science education" within the education domain. Specifically, they emphasize the use of gamification in the assessment of science subjects in primary education, comparing teachers' perceptions of gamification-based

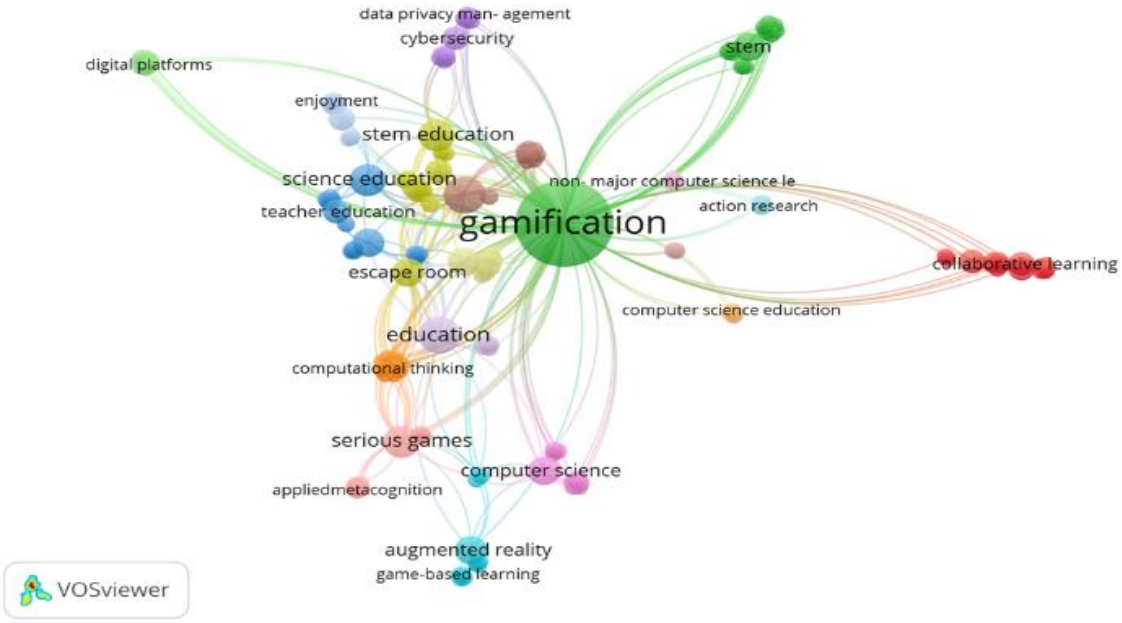
assessments with traditional exam-based processes (Rivas & Palmero, 2019).

From the 43 articles analyzed, 178 keywords were identified in gamification research within science education. To ensure statistical validity, a minimum occurrence threshold of one was set for each term, resulting in 20 qualifying keywords. The most frequent keyword was "gamification," which appeared 27 times, followed by "education" and "higher education," each with 5 occurrences, and "science education," appearing 4 times. This highlights the research focus on gamification within the context of science education across various educational levels.

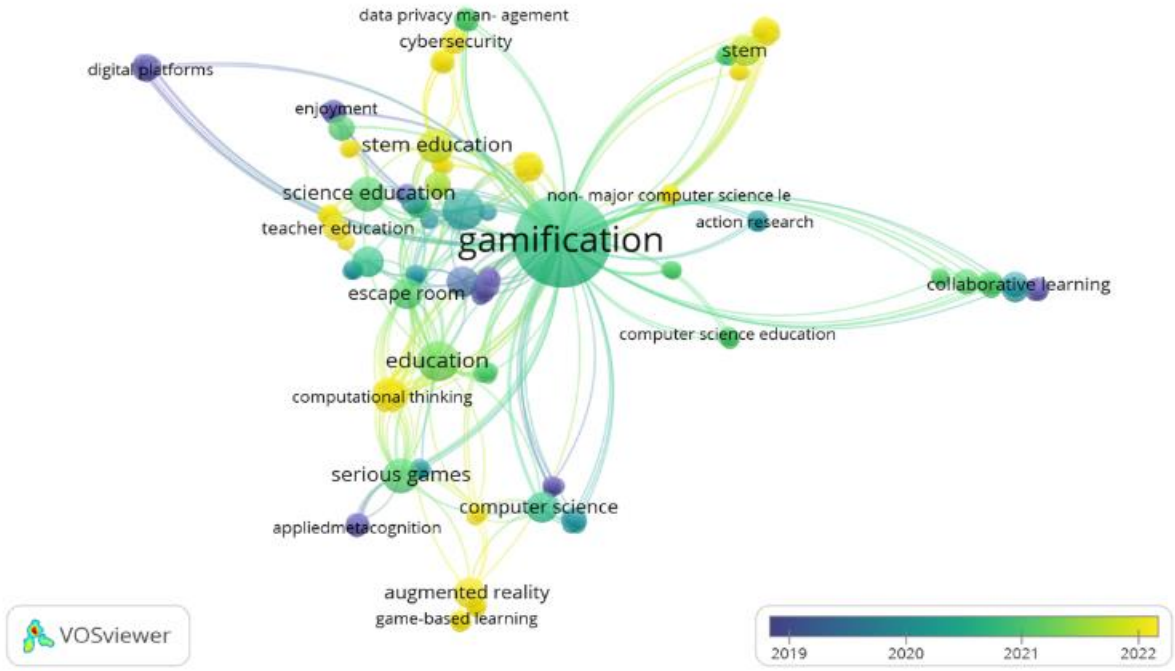
**Table 5**. Frequently Appearing Keywords

| Keywords | Occurrences | Total link strenght |
|---|---|---|
| Gamification | 27 | 146 |
| Education | 5 | 37 |
| Higher education | 5 | 29 |
| Serious games | 4 | 28 |
| Stem education | 4 | 23 |
| Science education | 4 | 21 |
| Escape room | 3 | 26 |
| Computer science | 3 | 17 |
| Motivation | 3 | 16 |
| Stem | 3 | 15 |
| Augmented reality | 3 | 13 |
| Collaborative learning | 2 | 14 |
| Medical education | 2 | 14 |
| Computation thinking | 1 | 13 |
| Digital education | 1 | 13 |
| Digital games | 1 | 13 |
| Digital health | 1 | 13 |
| Digital learning | 1 | 13 |
| Education games | 1 | 13 |
| Interactive learning environment | 1 | 13 |

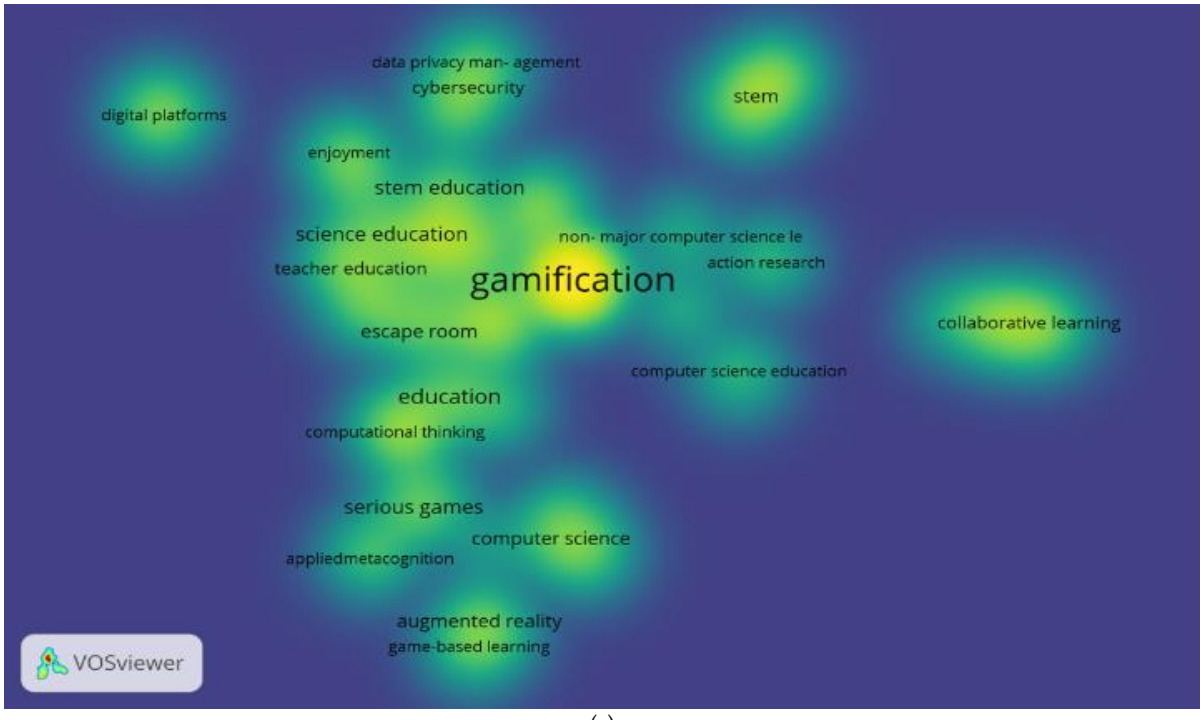
In the context of gamification, the keywords "gamification" and "education" appeared 27 and 5 times, respectively, while "science education" appeared 4 times. This indicates that gamification in science education within the educational domain remains a primary focus in gamification research (Čubela et al., 2023). Regarding the focus of gamification research in science education, Francisco highlighted that although students often perceive science as challenging, the use of innovative techniques improves their perception and motivation toward this discipline. Students also acquire new techniques that they can apply in their future professional activities (Zamora-Polo et al., 2019). This also emphasizes that gamification in science education is not merely about meeting students' needs but also offers significant benefits. It enhances student engagement and motivation while fostering a more interactive learning environment. This approach not only helps students gain a deeper understanding of scientific concepts but also contributes to the development of collaborative, communication, and problem-solving skills across all aspects of education (Zainuddin et al., 2020).




(a)




(b)




(c)

**Figure 6**. (a) Network visualization co-occurence, (b) Overlay visualization co-occurence, (c) Density visualization co-occurence

Figure 6 (a) visualizes the 178 identified keywords, of which all 178 met the minimum occurrence threshold, but only 21 were significantly interconnected. Consequently, only these keywords were included in the Co-occurrence of Keywords visualization. The figure illustrates how "gamification" is linked to "collaborative learning" and "science education." The strong connection between gamification and keywords such as "education" and "science education" underscores the importance of gamification in science education within the educational domain.

Figure 6 (b) provides a temporal perspective, highlighting shifts in keyword discussions between 2019, 2020, 2021, and 2022. The color changes from blue to yellow and then green in the visualization indicate that certain topics, such as "gamification," were more dominant in earlier periods, while themes like "science education" and "education" emerged later. This reflects the growing attention to gamification in education and its adaptation to support science education and address the diverse needs of students and educational settings over this period.

Figure 6 (c) illustrates the frequency and strength of relationships among keywords, with "gamification" at the center. Areas with higher intensity, such as around the keywords "gamification," "science education," and "education," indicate that these topics are frequently discussed and considered highly relevant in the gamification literature within science education. The connections between gamification and these topics reflect a strong focus on the importance of applying gamification in broader and more comprehensive science education contexts, particularly within the scope of education.

These visualizations provide a clearer picture of current research trends, identifying dominant topics in academic discussions within this field.

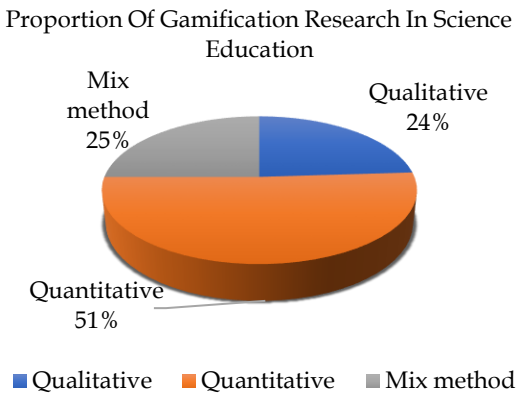



**Figure 7.** Proportion of Research Methods in Inclusive Education

The figure illustrates the distribution of research methods employed in 43 articles on gamification in science education from 2019 to 2023. Quantitative methods dominate the studies, accounting for 51% (23 articles), followed by mixed methods at 25% (11 articles), and qualitative approaches at 24% (10 articles). This distribution reflects the preference for quantitative methods among researchers studying gamification in science education, as these methods provide an objective and systematic way to measure variables. Quantitative research often employs tools such as questionnaires or tests to collect numerical data on students' mastery of concepts, motivation, and engagement. Using advanced statistical analyses, researchers can determine the relationship between gamification and student learning outcomes more accurately. Moreover, quantitative methods allow for generalizability, enabling findings to apply to broader populations when large and representative samples are used. This is particularly significant in science education, where the applicability of findings across diverse educational settings is critical. Quantitative research has been instrumental in demonstrating the broader benefits of gamification, such as enhancing motivation and improving learning outcomes at various educational levels (Irnawati et al., 2024).

In contrast, mixed-methods research, analyzed in 11 articles, highlights the dominance of case studies as the primary approach. All 11 mixed-methods articles utilized case studies to explore gamification in science education within real-life contexts, such as classrooms and other educational environments. This approach is often chosen to gain a deeper understanding of gamification's implementation and its effects on diverse educational settings. Case studies allow researchers to investigate how gamification strategies are adapted to address students' needs and overcome educational challenges. Unlike quantitative methods, which focus on numerical data, mixed methods provide nuanced insights into the practical applications and contextual factors influencing gamification's effectiveness. This comprehensive perspective enriches the understanding of how gamification contributes to student engagement, motivation, and collaborative learning in science education (Mahendra et al., 2023).

**Table 6.** Trends of the top five articles on gamification in science education (2019–2023)

| Title | Authors | Findings | Recommendations |
|---|---|---|---|
| Using online game-based platforms to improve student performance and engagement in | Szabolcs Felszeghy, Sanna Pasonen-Seppänen, Ali Koskela, Petteri Nieminen, Kai Härkönen1, Kaisa M. A. Paldanius, Sami Gabbouj, Kirsi | The results of this study show that incorporating Kahoot in histology instruction significantly improves student engagement and academic performance. More than 80% of participants stated that the platform provides a safe and anonymous space, enabling them to practice without the fear of judgment or | This study recommends that online game-based platforms such as Kahoot can be utilized as supplementary tools in histology teaching to enhance student engagement and performance. Additionally, the researchers suggest that instructors consider integrating gamification elements into their curricula |

| | | | |
|---|---|---|---|
| histology teaching | Ketola, Mikko Hiltunen, Mikael Lundin, Tommi Haapaniemi, Erkko Sointu, Eric B. Bauman, Gregory E. Gilbert, David Morton and Anitta Mahonen. | critical errors. Furthermore, students noted that Kahoot fosters a more relaxed environment for discussions and enhances the enjoyment of learning. The study also highlighted students' preference for team-based games over individual ones, emphasizing that gamification promotes collaborative learning while enhancing academic achievements. | to create a more interactive and enjoyable learning environment. |
| Use of Gamification Applications in Science Education | Cigdem Hursen, Cizem Bas. | The results of this study suggest that gamification applications have a positive effect on students' motivation to learn science. The research found that gamified elements enhance classroom participation and motivation while also improving students' communication skills and behavior. Moreover, parents expressed positive opinions, noting that gamification is both beneficial and effective in encouraging their children to engage in learning. | The study recommends integrating gamification elements into science education to enhance students' motivation and participation. Educators and curriculum developers are encouraged to use gamification applications as learning tools to make the learning process more engaging and interactive. Furthermore, ongoing research is necessary to explore the long-term impacts of gamification in various educational contexts and age groups. |
| Education of Preschool and Elementary Teachers on the Use of Adaptive Gamification in Science Education | Alkinoos-Ioannis Zourmpakis, Stamatios Papadakis and Michail Kalogiannakis. | This study discovered that gamification in science education can enhance students' motivation and engagement. It also revealed that the most effective and motivating game elements are those customized to individual needs, referred to as adaptive gamification. Furthermore, the study underlined the significance of teacher training for successful technology integration and highlighted the challenges educators encounter when implementing gamified learning environments. | The study recommends adequate training and support for teachers to integrate gamification into science education. Further research is suggested to explore various game elements and how they can be tailored to meet individual student needs through adaptive gamification. Future studies could also focus on developing better evaluation tools to measure the effectiveness of gamification in educational contexts |
| Gamification in engineering education – An empirical assessment on learning and game performance | Jenny Díaz-Ramírez. | The findings of this study show that gamification has a positive effect on academic performance and promotes desirable social behaviors, including teamwork and a sense of community. The research offers empirical evidence that integrating game elements into engineering education improves learning processes and boosts student motivation. | The study recommends integrating more gamification elements into engineering education curricula to improve student motivation and engagement. Additionally, further research is needed to explore the long-term impacts of gamification on learning outcomes and to evaluate different game elements applicable in diverse educational settings. |
| Using Gamification in a Teaching Innovation Project at the University of Alcalá: A New Approach to Experimental Science Practices | Dolores López Carrillo, Amelia Calonge García, Teresa Rodríguez Laguna, Germán Ros Magán and José Alberto Lebrón Moreno. | The findings of this study show that applying gamification in science laboratory practices successfully increased student motivation and engagement. However, the study could not confirm that gamification significantly improved learning outcomes. Gamification enabled students to develop more competencies compared to regular laboratory practices, but significant learning gains were not observed. Additionally, the use of applications like Kahoot and ClassDojo enhanced student participation and awareness of their work. | The researchers recommend further studies to explore gamification's impact on more meaningful learning outcomes. They also suggest developing and testing more gamification tools and methods across different educational contexts to better understand their effectiveness. Additionally, the researchers recommend considering student preferences and player types when designing gamified activities to enhance motivation and engagement. |

Table 6 reflects the latest research trends in gamification within science education over the past five years (2019–2023), highlighting the importance of gamification in the educational domain. Research by Zourmpakis et al. (2022) indicates that the use of gamification in science education has the potential to

enhance student motivation and engagement. This study also found that the most beneficial and motivating game elements for students are those tailored to their individual needs, referred to as adaptive gamification.

Additionally, findings from Felszeghy et al. (2019) demonstrate that using Kahoot in histology teaching improves student engagement and performance. Over 80% of students reported that the platform created a risk-free and anonymous environment, allowing them to practice without fear of judgment or critical mistakes. Furthermore, students noted that Kahoot fostered a more relaxed atmosphere for discussion and increased their enjoyment of learning. The study also revealed that students preferred team-based games over individual games, with gamification supporting collaborative learning and improving academic outcomes. Similarly, Hursen & Bas, (2019) found that gamification applications positively impact students' motivation to learn science. Their research highlighted that gamified elements enhance classroom participation, motivation, and positively influence student communication and behavior. Moreover, parents provided favorable feedback, stating that gamification applications are beneficial and effective in motivating their children to learn. Díaz-Ramírez (2020) offered insights into gamification's positive effects on academic performance and desirable social behaviors, such as teamwork and a sense of community. The study provided empirical evidence that game elements in engineering education enhance learning processes and student motivation.

Finally, research by Carrillo et al. (2019) revealed that implementing gamification in science laboratory practices successfully increased student motivation and engagement. However, the study could not confirm significant improvements in learning outcomes. Gamification enabled students to work on more competencies compared to standard laboratory practices, although meaningful learning gains were not guaranteed. The use of applications like Kahoot and ClassDojo further improved student participation and self-awareness regarding their tasks.

## Conclusion

This research shows that gamification in science education has gained global attention, with significant contributions from 21 countries participating in publications related to this topic between 2019 and 2023. Spain emerged as the leader in terms of the number of publications, followed by countries such as the United States, Malaysia, and several others, including Mexico, Germany, Greece, and Finland. The fluctuations in the number of publications and citations reflect the complex dynamics in this field, influenced by various internal and external factors. Collaboration among researchers, educators, and policymakers has proven to be a key factor in developing and implementing effective gamification strategies. The findings of this study indicate that gamification can enhance motivation, engagement, and conceptual understanding of science among students. This research also emphasizes the importance of cross-country and interdisciplinary collaboration to expand the application of gamification in science education, as well as creating opportunities for further research that can accelerate the adoption of this method worldwide.

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**Author Contributions**

The contributions of each author to this study are as follows: A.S. contributed to the conceptualization, methodology, writing—original draft preparation, as well as the results and discussion. U.M. was responsible for validation, methodology, and writing—reviewing. L.S.R. provided supervision and contributed to the conclusion. A.S. assisted with the conclusion and manuscript review. S. and Q.S. supported the conclusion and reviewed the manuscript.

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**Conflicts of Interest**

The authors declare no conflict of interest.

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