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Research Trends of Gamification in Science Learning Over the Decade and the Impact in Physics

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Abstract: The physics learning environment often causes cognitive load on students. Designing a physics learning environment that is friendly to students' cognitive load is a challenge for teachers. This study aims to analyze research topics on gamification in science learning and its impact on physics over the past decade. This research was conducted through bibliometric analysis, combined with a literature review. Data obtained from Scopus publications. The research trend on gamification in science learning increased over the decade, from 2016 to 2025. The United States is the country with the most publications on this topic. The 125 publications in conference papers represent the largest number of publications on this topic. The most frequently used keywords, based on network analysis, include gamification, computer science education, science education, STEM education, augmented reality, and computer-aided instruction. Gamification in science learning has a positive impact on physics. Gamification has an impact on increasing student engagement and creativity, motivation and interest in learning, in-depth understanding of concepts, and self-efficacy. The results of this study provide insight into the need for further research on gamification innovations in physics concepts and on the design of digital technologies for gamification-based physics learning.

Keywords: Bibliometric; Gamification; Physics; Science learning; Technology

Introduction

Science learning is considered a challenging subject for students. Students often struggle to grasp the concepts involved, particularly in physics (Evendi et al., 2024). An inappropriate science learning environment leads to students' lack of interest in learning physics concepts. Consequently, students struggle to grasp scientific concepts, particularly physics. Lack of student engagement in science learning activities significantly contributes to low learning outcomes (Malahito & Quimbo, 2020). This presents a challenge for teachers to create learning innovations that create a fun, motivating, and active student engagement atmosphere, enabling students to better understand physics concepts through the process of constructing their own conceptions. Appropriate learning media are needed to support these learning activities (Lasiani & Setiono, 2025)

Furthermore, the integration of learning media into science learning activities, particularly physics, needs to be well-designed. Various learning strategies have been implemented in science learning. However, teachers' ability to master technological, pedagogical, and content knowledge competencies is essential (Salleh et al., 2025; Wahono et al., 2025). One such learning design is integrating gamification strategies into science learning activities, particularly physics (Richter & Kickmeier-Rust, 2025).

Gamification is a strategy that has gained significant traction in recent years for improving learning outcomes and student engagement (Deterding et al., 2011). Furthermore, gamification makes learning more engaging, thus influencing student motivation and interest in learning, as well as student attitudes and performance (Hazan et al., 2018; Malahito & Quimbo, 2020). Through gamification, students can connect various learning tasks to their interests, thus fostering more positive attitudes, such as being able to actively contribute to learning activities (Zaric et al., 2021; Karabıyık, 2024). Gamification is seen as a solution for creating a fun science learning atmosphere that supports deep conceptual understanding and cognitive engagement (Özhan & Kocadere, 2020), both in digital and hybrid formats (Torres-Toukoumidis & Vallejo-Imbaquingo, 2024). Furthermore, in addition to improved learning outcomes, students' social skills can also improve through gamification (Klubal et al., 2018). Several previous studies have examined gamification in science learning (Katanosaka et al., 2024; Torres-Toukoumidis & Vallejo-Imbaquingo, 2024; Zappalá et al., 2025). However, there are not many literature-based studies that comprehensively analyze the results of research on this topic. Although there have been several literature-based studies on gamification in science learning, such as Lampropoulos et al. (2022), Gaurina et al. (2022), Nurfadilah et al. (2025), and Rai & Gurung (2026). However, these existing studies have not examined in depth the impact of gamification on physics. Research conducted by Gaurina et al. (2022) revealed that gamification components can enhance motivation, engagement, and academic achievement among students studying physics; however, the study did not examine aspects of physics in depth, such as physics concepts. Patar et al. (2024) describe gamification through the use of quizzes and a point system for basic physics concepts, but do not discuss the impact of gamification on abstract physics concepts. Ferreira, Fillo, & Ferreira (2019) describe the use of technology for gamification in physics, but the technology is only described in general terms. This is despite the fact that physics is one part of science learning that is considered difficult for students (Sarabi & Gafoor, 2018). Furthermore, this research is expected to provide alternative solutions for creating enjoyable physics learning designs for students while simultaneously improving their learning outcomes. This is because the research combines bibliographic and literature studies of research findings related to the topic of gamification in science learning. Research trends on this topic can be identified through bibliometric studies. Meanwhile, a more in-depth analysis of research on this topic is conducted through a literature review.

Bibliometrics is a research method that provides scientific knowledge derived from an in-depth, systematic analysis of the research literature that has emerged on a given topic (Agbo et al., 2021; Pranckutė, 2021; Vieyra & Himmelsbach, 2022). Therefore, bibliometric studies use empirical data from published research. This analysis can be based on publication type, year of publication, country of origin, author, and so on (Mustapha et al., 2021). Knowledge network analysis in bibliometrics, such as co-citation and co-authorship analysis, can reveal relationships among authors, research results, and affiliations that have implications for further research (Amiruddin et al., 2025). This can help identify established collaboration patterns, which is difficult to do with manual qualitative reviews. Meanwhile, a literature review method was used to analyze previous research findings in greater depth. This method was employed to conduct a comprehensive and in-depth analysis of studies related to gamification in science education and its impact on physics.

This study was conducted to describe the importance of gamification in science learning and its impact on physics. This study analyzed publications related to gamification in science learning over a decade, from 2016 to 2025. This research aimed to address fundamental questions.

RQ1: How have the research trends on gamification in science learning changed over the past decade?

RQ2: What are the most frequently used keywords, countries, and authors who have contributed to this gamification research over the past decade?

RQ3: How are the document types and source titles of the top 10 cited publications over the past decade?

RQ4: How is the distribution of the number of publications and citations over the past decade?
RQ5: How is the impact of gamification on physics?

Methods

This research was conducted by combining bibliometric analysis and literature review (Agbo et al., 2021; Pranckutė, 2021; Ampese et al., 2022; Lampropoulos et al., 2022). Bibliometrics provides information on the latest research developments in a field, as well as its trends and developments (Xie et al., 2020; Donthu et al., 2021; Prahani, Amiruddin, Jatmiko, et al., 2022). Furthermore, bibliometrics can also visualize specific patterns of relationships between studies (González-Pérez, 2023). The research data was obtained through

Scopus (Xie et al., 2020; Yirci et al., 2023) for publications from 2016 to 2025. Publication data from Scopus was selected because it is the world's largest publication database, covering a wide range of scientific fields and offering easy access (Pranckutė, 2021; Shubina et al., 2021). The researchers conducted a literature search using a Boolean algorithm using the keywords "gamification" AND "science education" OR "science learning" OR "physics education" OR "physics learning". The research data was collected on February 8, 2026.

The initial search using the entered keywords yielded 306 publication data. The researchers screened the data based on publication titles, authors, and countries. Based on the results of this screening, 18 publications were identified in the Scopus database for which the publication titles could not be identified. In addition, the author IDs and countries for these 18 publications could not be identified. Thus, 288 publications were used for analysis. The data is extracted in CSV format and then processed in Microsoft Excel (Gillani et al., 2022; Suliyanah et al., 2024; Setiono et al., 2025). Meanwhile, data from Scopus in RIS format was used for analysis using VOSViewer (Xie et al., 2020; Matulaitienė, 2021; Gillani et al., 2022; Setiono et al., 2025). Microsoft Excel and VOSviewer were used to produce beautiful visualizations, including graphs, tables, diagrams, and maps (Prahani, Amiruddin, Suprapto, et al., 2022). The flowchart of the research conducted is shown in Figure 1.

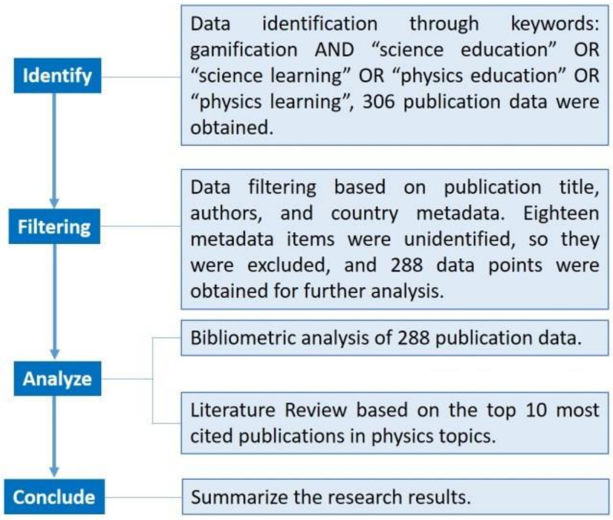

Fig. 1. Research flowchart

Results and Discussion

Based on the data analysis that has been carried out, this research has reached results to answer the research questions.

Research trends over the decade

Publication trends show the number of publications produced by researchers over a specific time period. Publication trends related to gamification in science learning and its impact on physics are shown in Figure 2.

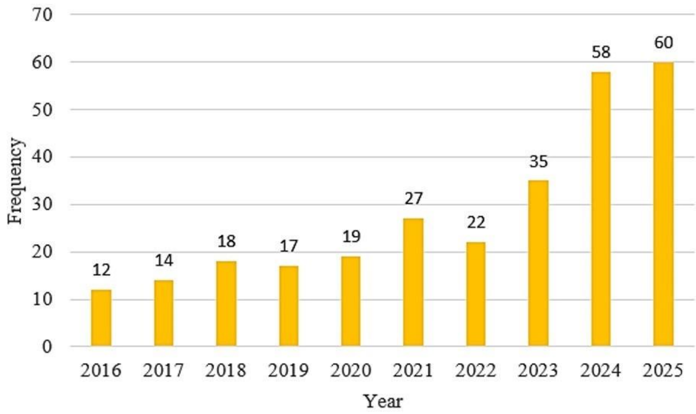

Fig. 2. Publication trends each year

Figure 2 shows that the highest number of publications on the topic of gamification in science learning occurred in 2025, with 60 documents. Meanwhile, in 2016, the number of publications was at its lowest. The trend of gamification publications increased from 2016 to 2025. The peak increase in the quantity of publications occurred in 2024, namely 23 documents. This is due to the post-pandemic effects of COVID-19 (Rey-Martí et al., 2026). In addition, the acceleration of digital transformation and Artificial Intelligence (AI) has driven an increase in the productivity of scientific publications (Mangubat & Saeedi, 2025). This transformation offers benefits across various stages of research, such as literature search, data analysis, and the writing of scientific articles. Overall, the research trend on the topic of gamification in science learning has increased over the past decade.

The most frequently used keywords, countries, and authors who have contributed to this gamification over the past decade

Network analysis using VOSviewer of keywords was conducted to determine relationships among publications on the topic of gamification. In addition, this analysis is used to identify further research opportunities related to the topic of gamification in science learning. The results of the network analysis are shown in Figure 3.

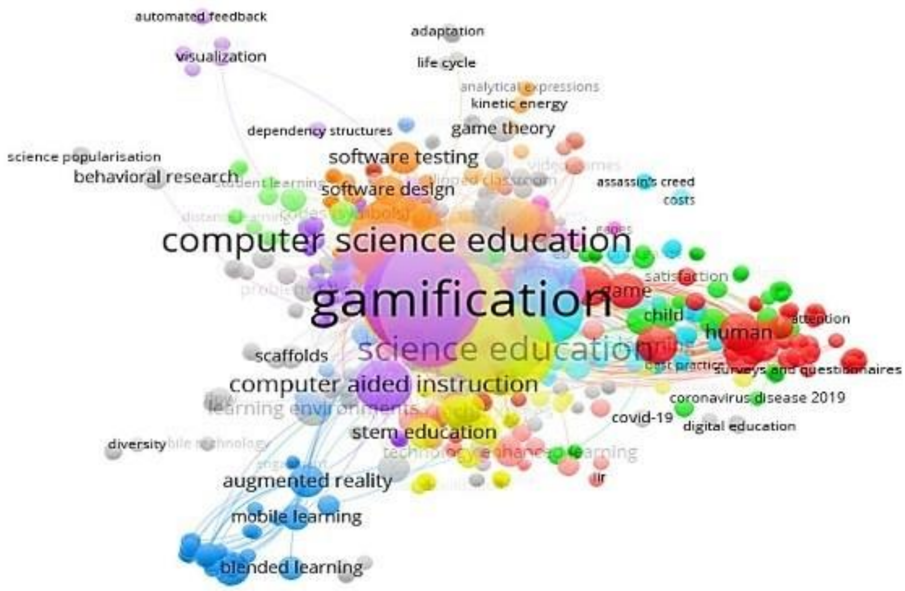

Fig. 3. Gamification research network visualization in science learning

Figure 3 shows the relationship patterns between keywords in publications on gamification in science learning over a decade. Network analysis in VOSViewer shows the keywords used in research and the relationships between clusters, highlighting frequently used and rarely used keywords based on the size and brightness of the resulting keyword cluster visualization (Oyewola & Dada, 2022; Yang & Thoo, 2023; Kumar et al., 2024). Furthermore, the network also explains interest in the research topic, its development, and its relevance to the topic (Chen et al., 2021; Fitriani et al., 2023; Kumar et al., 2024). Within this topic, the most frequently used keywords include gamification, computer science education, science education, STEM education, augmented reality, and computer-aided instruction. The network analysis also shows that learning environments, augmented reality, gamification, and science education are not directly related, creating opportunities for further research. In addition to network visualization, VOSViewer also displays the results of an overlay analysis, which explains the time trends of research on a topic. An overlay analysis of the topic of gamification in science learning in this research is shown in Figure 4.

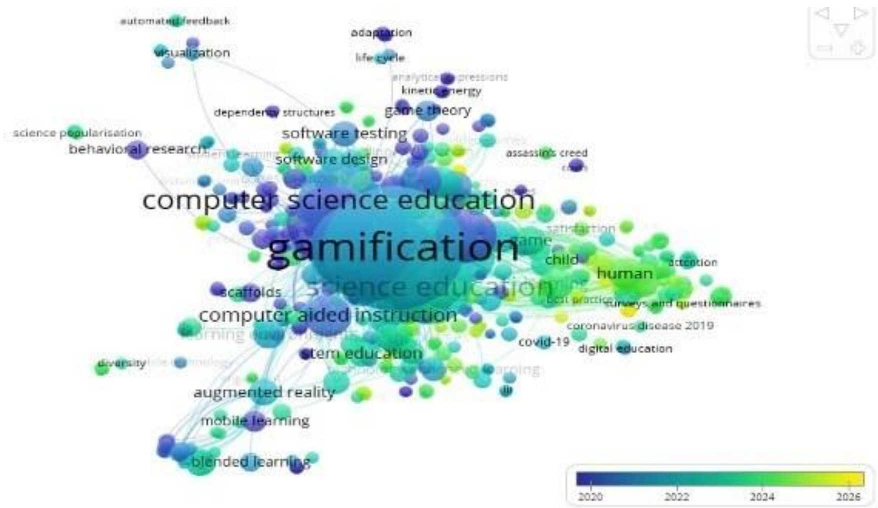

Fig. 4. Gamification research overlay visualization in science learning

Figure 4 shows the results of an overlay visualization of gamification research in science learning. The visualization results for the period from 2016 to 2025 show that the darker the color of a keyword, the more popular that research topic was in the past. Conversely, the brighter the color of a keyword, the more popular that research topic has been recently. Figure 4 shows that gamification and science education have been popular research topics since 2022. Although research related to computer-aided instruction has been popular since 2020, research on augmented reality, learning environments, and STEM education only became popular starting in 2022.

The results of this study reveal that publications on gamification in physics learning are from various countries. The top 10 countries contributing the most publications on this topic are shown in Figure 5.

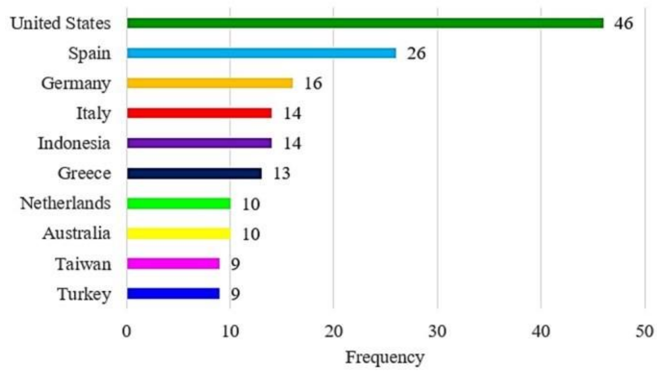

Fig. 5. Top 10 countries with the most publications over the decade

Figure 5 shows the distribution of countries producing publications on the topic of gamification in science learning, based on the top 10 publications over the past decade. Figure 5 shows that the United States produced the most publications over the decade, with 46 documents. On this topic, Italy and Indonesia had the same number of publications over the decade, ranking fourth with 14 documents. The Netherlands and Australia have a similar quantity of publications, as do Taiwan and Turkey have a similar quantity of publications on this topic over the last decade. An author analysis of each publication was conducted to identify the top 10 authors who generated the highest number of citations in publications related to the topic of gamification in science learning. The researchers used VOSViewer and Microsoft Excel to conduct this analysis. The results of the author analysis are presented in Table 1.

Table 1. Top 10 authors with the most citations over the past decade

Author	Number of citations	Number of citations per year	Country
S. Papadakis	760	76	Greece
G. Jiménez-Valverde	26	2.6	Spain
M. Kalogiannakis	700	70	Greece
A.I. Zourmpakis	700	70	Greece
S.O. Semerikov	180	18	Ukraine
A.M. Stiuk	180	18	Ukraine
M. Giannakos	14	1.4	Norway
S. Papavlasopoulou	14	1.4	Norway
K. Richter	8	0.8	Switzerland
G. Delzanno	9	0.9	Italy
G. Jiménez-Valverde	760	76	Greece
M. Kalogiannakis	26	2.6	Spain
A.I. Zourmpakis	700	70	Greece
S.O. Semerikov	700	70	Greece
A.M. Stiuk	180	18	Ukraine
M. Giannakos	180	18	Ukraine

Table 1 shows the top 10 authors with the highest number of citations on the research topic of gamification in science learning. S. Papadakis from Greece generated the highest number of citations in research on gamification in science learning, with a total of 760 citations. Furthermore, through VOSViewer, connections between authors are visible. Thus, we can identify and classify authors (Effendi et al., 2021). Grouping and correlation between authors produce a research cluster (Pristianti, 2022). The results of the analysis in this study indicate that there are five clusters, each consisting of several members. The more correlations generated, the more frequent collaborations between authors related to research on this topic. The results of the correlation analysis between authors are shown in Figure 6.

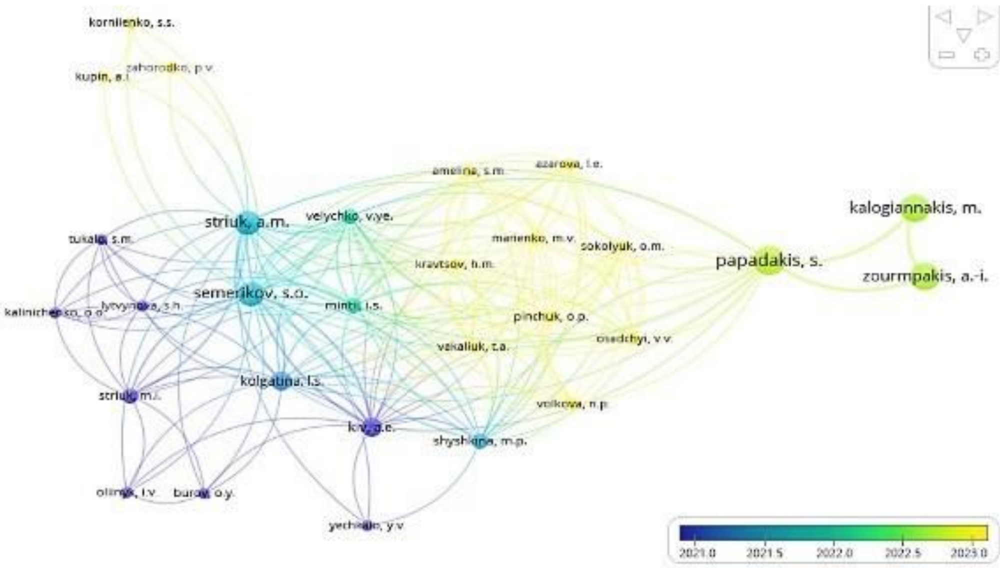

Fig. 6. Visualization of correlation between authors

Figure 6 shows a visualization of the network between authors. S. Papadakis is the author who has published the most on gamification in science learning and has numerous collaborations, as do M. Kalogiannakis, A.I. Zourmpakis, M.P. Shyshkina, V. Ye. Velychko, I.S. Kolgatina, and S.O. Semerikov. The visualization shows many large, clustered nodes. This indicates that research collaboration on the topic of gamification in science learning is intensive and integrated. Broad collaboration, such as between countries, affiliates, and researchers, significantly promotes the advancement of knowledge in a scientific field because it can form a mutually supportive global network, expanding the scope of research and creating high-quality research (Pfotenhauer et al., 2016; Faria et al., 2024 Amiruddin et al., 2025). Collaboration between countries allows for the formation of new ideas that emerge from the exchange of ideas from more than one perspective. Meanwhile, the same cluster in a study promotes knowledge development through strong collaboration skills, thereby generating simultaneous outcomes (Bleem et al., 2020; McAllister et al., 2022; Suliyanah et al., 2024; Amiruddin et al., 2025).

Document Types and Source Titles of the Top 10 Cited Publications Over the Decade

An analysis of document types was conducted to determine the types of publications used by authors to publish their research on gamification in science learning. The document types identified in the research on this topic are described in Table 2.

Table 2. Top 10 most used document types over the decade

Document type	Frequency	Number of citations	Average number of citations
Conference paper	125	1142	9.1
Article	118	2780	12.6
Conference review	18	0	0
Review	13	249	19.2
Book chapter	11	74	6.7
Editorial	1	9	9
Erratum	1	0	0
Letter	1	3	3

Table 2 shows that authors published more research on gamification in physics learning in conference papers, totaling 125 documents over the past decade. Articles ranked second with 118 documents. This is because conference papers are more practical and have a clear, accessible impact, as they are presented and witnessed by experts from various fields at conferences (Liu et al., 2013; Prahani, Amiruddin, Jatmiko, et al., 2022). Despite this, conference papers top the list of document types, with fewer citations generated over the decade. Based on the average number of citations generated, articles have greater potential than conference papers. Meanwhile, conference reviews and erratums offer potential for publication, although none have been cited in the past decade.

In line with the document types, a source title analysis was conducted to identify potential sources for publishing gamification research in science learning over the past decade. The results of the analysis of the top 10 published source titles are presented in detail in Table 3.

Table 3. Top 10 source titles for a decade

Source title	Number of documents	Number of citations
AMC International Conference Series	11	57
Communications in Computer and Information Science	10	36
Education Sciences	8	683
Education and Information Technologies	7	235
Ceur Workshop Proceedings	7	181
Annual Conference on innovation and Technology in Computer Science Education Iticse	6	22
Proceedings of the European Conference on Games Based Learning	5	13
Advances in Intelligent Systems and Computing	5	19
Lecture Notes in Networks and Systems	4	33
International Journal of Information and Education Technology	4	14

Table 3 shows the top 10 publication sources for gamification research in science learning over the past decade. The results indicate that the AMC International Conference Series is the most popular source for research publications on this topic. This is because conference papers have greater influence due to their greater accessibility since the articles are presented at conferences (Liu et al., 2013). However, Education Sciences, ranked third among the sources with eight documents, had the highest number of citations over the decade. Therefore, based on the results of the analysis conducted in this study, the AMC International Conference Series offers greater opportunities for publication. Meanwhile, Education Sciences has offered significantly greater citation opportunities over the past decade. This suggests that choosing a good publication venue, such as a journal, is a crucial step in research (Nicholas et al., 2022). Several factors to consider include the scope of the research in the publication, its quality (such as reputation and ranking), and the impact factor of the published research. Selecting a good publication place will increase the chances of research results being reached by other researchers, thus having an impact on the research (Tracy, 2019). Furthermore, publications increase the chances of being cited. Good articles are published in journals or proceedings indexed by Scopus and Web of Science (Singh et al., 2022). Meanwhile, the H-index and indexation are the most important indicators of a journal's impactfulness, so they should be considered during publication (Roldan-Valadez et al., 2019; Michel-Villarreal et al., 2023; Rushton et al., 2023; Amiruddin et al., 2025).

Distributions of the Number of Publications and Citations Over a Decade

An analysis of the number of citations generated each year on the topic of gamification in science learning was conducted to determine the chances of documents being cited on this topic. The results of the analysis of the number of citations to publications on this topic over a decade are explained in Table 4.

Table 4. Number of publications and citations over a decade

Year	Citation year	Gamification			
		Number of citations	Number of documents	Average citations per publication	Average citations per year
2016	10	58	12	4.8	0
2017	9	562	14	40.1	4.5
2018	8	170	18	9.4	1.2
2019	7	283	17	16.6	2.4
2020	6	341	19	17.9	3.0
2021	5	779	27	28.9	5.8
2022	4	259	22	11.8	2.9
2023	3	500	35	14.3	4.8
2024	2	249	58	4.3	2.1
2025	1	83	60	1.4	1.4

Table 4 shows the number of citations to publications on gamification in science learning each year over a decade. Based on the results of this study, it is known that 2025 had the highest number of published documents on this topic, namely 60 documents. Research trends over the decade indicate that research on this topic has been steadily increasing. This is evidenced by the increasing number of published documents each year over the decade. The highest number of citations was in 2021. This occurred because in 2019, the world of education experienced the COVID-19 pandemic. Gamification learning, as a solution to reduce students' cognitive load during the pandemic, became an alternative learning option. The trend in the number of citations generated each year over the past decade has been on the rise. The growing trend of gamification has coincided with the use of digital technology in education. Furthermore, the increase in the number of publications on this topic has led to a rise in the number of citations generated. The number of citations indicates the quality of the published articles (Rose & Johnson, 2020; Costa et al., 2021; Aksnes et al., 2023). The number of citations is influenced by many factors, such as the publication venue (journal/proceedings), the quality of the journal/proceedings, and the impact factor of the publication venue. Choosing a good publication venue, such as a journal, can increase the visibility of research results (Amiruddin et al., 2025).

Literature Review on the Impact of Gamification in Physics

Based on the analysis, this research ranks among the top 10 most cited papers with a direct impact on physics. These top 10 papers are presented in Table 5.

Table 5. Top 10 most cited and impactful papers in physics

Author	Number of citations	Research findings
Richter, K. & Kickmeier-Rust, M. (2025)	37	Gamification in physics learning increases students' activeness and motivation to learn, and encourages a deep and retentive understanding of complex physics scientific concepts.
Zourmpakis, A.-I. , Kalogiannakis, M. & Papadakis, S. (2023)	36	Gamification can increase student engagement, motivation, and learning outcomes. However, teachers need to understand the TPACK framework well.
Ahmed, H.D. & Asiksoy, G. (2021)	17	Gamification in physics flipped-classroom has a positive impact on students' innovation skills and self-efficacy.
Amado, C.M. & Roleda, L.S. (2020)	15	Gamification in physics learning can encourage student engagement very well.
Leuzinger, S. , Borrelle, S.B. & Jarvis, R.M. (2019)	12	Effective smartphone apps provide easy-to-understand and relevant scientific information on global warming, alongside scientific journals. They also support science learning.
Radnai, T. , Tóthné Juhász, T. , Juhász, A. & Jenei, P. (2019)	9	Using a physics simulation program helps students understand the conceptual differences between distance, displacement, and velocity. Furthermore, it enhances creativity and the ability to establish relationships between graphs. The simulation program is suitable for students with intermediate to advanced abilities.
Saprudin, S. , Liliasari, S. , Prihatmanto, A.S. & Setiawan, A. (2019)	9	The map of thinking styles and critical thinking abilities of pre-service physics teachers determines the gamification model in physics learning.
da Silva, J.B. , Sales, G.L. & de Castro, J.B. (2019)	8	Gamification in physics learning improves physics learning outcomes, compared to physics learning without gamification.
Iquira, D. , Sotelo, B. & Sharhorodska, O. (2019)	8	A mobile gamification-based virtual reality laboratory improves physics learning outcomes and student motivation. While effective in practical applications, this laboratory does not replace the teacher's role; rather, it complements learning.
Becerra, D.A.I. , et.al. (2017)	6	3D virtual reality-based gamification has high didactic utility and improves conceptual understanding of motion.

A literature review reveals that gamification in physics learning offers numerous benefits. Through gamification in physics learning, students become more actively engaged in learning because their motivation and interest in learning increase. Consequently, student learning outcomes in physics learning improve significantly. Students are not only able to improve their creativity, innovation, and skills in understanding graphs, but also develop a deep and retentive conceptual understanding of complex concepts. The presence of digital technology in gamified physics learning makes learning more engaging, interactive, and enjoyable (Katanosaka et al., 2024; Lampropoulos et al., 2022; Zappalá et al., 2025).

Conclusion

Bibliometric research and literature review on gamification in science learning and its impact on physics yielded several conclusions. The trend of gamification research in science learning has increased over the past decade, from 2016 to 2025. The sharpest increase in the number of publications occurred in 2024. A bibliometric analysis of research conducted over the past decade shows that the most frequently used keywords in this field are gamification, computer science education, computer-assisted instruction, and science education. The integration of technologies such as augmented reality into digital learning, whether through mobile learning, blended learning, flipped classrooms, and STEM, offers significant opportunities for further research. The United States has been the leading contributor to gamification research in science learning over the past decade. Meanwhile, Indonesia ranks fifth in research on this topic. Richter, K. & Kickmeier-Rust, M., from Greece, are the most cited authors in gamification research impacting physics. Conference papers contribute the most to the publication of this topic. The highest source title on this topic is the AMC International Conference Series. The highest average number of citations per year was in 2021, with a quantity of 5.8. The high number of publications by authors from various countries underscores the importance of gamification in science education. The research topic of gamification in science learning has an impact on physics. Gamification enhances engagement, motivation, active participation, innovation skills, self-efficacy, learning outcomes, conceptual understanding, and high retention of physics concepts. Gamification can be implemented in physics experiments. The integration of digital technologies such as simulation, virtual reality, and augmented reality encourages better physics learning outcomes. Research on gamification in science learning and its impact on physics provides implications for gamification innovation in physics concepts, as well as digital technology-based learning designs in physics learning through gamification. This research is limited to the Scopus database within the last decade. Further research on this topic provides opportunities to be conducted in other databases.

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