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Bibliometric analysis: Trends of gamification in physics learning from 2019 to 2023

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Abstract: This research aims to analyze research trends related to the topic of Gamification from 2019 to 2023* through bibliometric analysis using the Scopus database. Based on the criteria, 56 articles were obtained from 326 documents. These articles have been translated from international journals indexed by Scopus. The selection references were then managed using reference management software, namely Mendeley. After working on the database, this research classifies and visualizes it using VOSviewer software. The results indicate that Gamification research is gradually increasing every year. The United States, China and Japan contribute the most research globally. Visualizing gamification research trends for 2019-2023* reveal six clusters. The results of this research can support researchers regarding Gamification research trends worldwide and provide direction for further research. Overall, these reflections provide an excellent reference point for further research on Gamification
Keywords: bibliometric analysis; VOSviewer; gamification; physics learning

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Introduction

The era of the 4.0 industrial revolution (the 4.0 Era) emphasizes digital economy patterns, artificial intelligence, big data, robotics, and so forth, known as disruptive innovation phenomena (Nurcholiq, 2019; Oo et al., 2022; Yuniani et al., 2019). The 4.0 Era has direct and indirect impacts on most aspects of human life, including in the field of Education (Annisa et al., 2023; Lukman Hakim, 2021; Khairunnisa & Ilmi, 2020; Nuraeni & Rosana, 2023; Rohman & Ningsih, 2018). Learning materials can be understood more easily through digital technology and online media to search for teaching materials, examples of questions and discussions, as well as applications of teaching materials implemented in daily life. Therefore, digital technology and online media play a crucial role in the field of Education today.

However, in current Education, the implementation of direct learning systems that seem monotonous and boring is still found, resulting in a decrease in students' learning motivation. Gamification in self-learning is one approach or method that can enhance students' learning motivation because it can have positive effects, namely enhancing motivation, perseverance, activity, and involvement of students in the learning process (Aini et al., 2021; Dichev & Dicheva, 2017; Groening &

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Binnewies, 2019). Gamified learning is an educational approach to motivate students to learn using video game designs and gaming elements in the learning environment (Kapp, 2012; Rahmania et al., 2023; Solviana, 2020; Srimuliyani, 2023). Gamification has been used in the field of Education and has been adopted as a learning tool to solve problems using or applying game mechanisms (Aguiar-Castillo et al., 2020; Firdaus & Faisal, 2021; Lutfiani et al., 2022). The goal is to maximize enjoyment and engagement of students, thus inspiring and increasing their interest in continuous learning.

Challenges still exist in physics learning, one of which is students perceiving physics as a difficult and boring subject (Juminah, 2017; Lestari et al., 2021; Sriyanti & Kurniati, 2021). Thus, to increase learning motivation and understanding of physics, students need to implement learning that can demonstrate the relationship between concepts and equations (Ekawati, 2018; Rahimah, 2022; Suliyanah et al., 2021). One effort to increase students' motivation is to make activities interesting and enjoyable, thus achieving maximum or satisfying learning outcomes using modern information technology, computers, the internet, and mobile phones (Syahrijar et al., 2023; Tinedi et al., 2018).

Gamification is the application of game design to a learning context (Firdaus & Faisal, 2021; Marisa et al., 2022; Mukarromah & Agustina, 2021). The application of gamification has gained many benefits, including (1) more than 90% of participants are interested in participating in mathematics learning using the gamification model (Kristanto, 2020; Ristiana & Dahlan, 2021), (2) there is a positive impact on students in learning the Arabic language (Jasni et al., 2019; Mulia et al., 2023), (3) effectively increasing digital literacy and student engagement in English learning (Pambudi et al., 2019; Sari & Nurani, 2021), (4) increase concentration and focus on children in civic education (Januar, 2023; Pradnyana et al., 2020), and (5) there is a positive influence on student activities in science learning in elementary schools (Sudana et al., 2021; Twiningsih Negeri Laweyan No & Surakarta, 2023). However, its application in physics learning is still rare. Therefore, based on previous research, further study is needed to integrate gamification into physics learning. Thus, this study aims to assess the current literature on gamification in physics learning and its relationship with learning motivation. Therefore, bibliometric analysis related to gamification was conducted to provide knowledge insights about gamification in order to evaluate the most cited sources, authors, countries, and keywords related to gamification. This bibliometric study provides important insights into emerging research trends regarding gamification. This bibliometric analysis also identifies networks that may be interesting to explore related to the novelty of research.

Method

This research is a type of bibliometric analysis (Merigó & Yang, 2017; van Nunen et al., 2018). The bibliometric analysis steps consist of five stages (Figure 1), including 1) research design; 2) data collection; 3) data analysis; 4) data visualization; and 5) interpretation (Misbah et al., 2022; Rukmana et al., 2023; Zupic & Čater, 2015). The first step includes research questions: a) What is the number of publications about gamification in physics learning from 2019 to 2023? b) what keywords appear in gamification in physics learning based on co-occurrence analysis using VOSviewers? c) What physics topics have implemented gamification in their learning? d) what types of research are used in gamification research in physics learning? e) How is gamification applied to physics learning based on the research subject? and f) Who are the five best authors based on the number of citations on gamification in physics learning?

The second data collection step was conducted in December 2023, based on the criteria obtained, resulting in 56 articles from 326 documents. These articles have been analyzed from international journals indexed in Scopus. The third step is data analysis, namely, data from Scopus stored in RIS and CSV formats, and Mendeley Desktop was mainly used to rearrange article metadata. VOSviewer software was used as a bibliometric analysis tool to visualize networks such as authors, countries, journals, and keywords (Hakim, 2020; HAmidah et al., 2020; Machmuda et al., 2022; Zakiyyah et al., 2022). This data was inputted for co-authorship and co-occurrence analysis to generate networks of authors, countries, journals, and keywords. Additionally, from citation analysis, a network map of scientific journals was produced. Langkah keempat yaitu data visualization menggunakan VOSviewer

software version 1.6.18 was used for constructing and visualizing bibliometric networks. This software provides an overview of publication information, such as authors, organizations, countries, and keywords. VOSviewer as a visualizer of research trend data with the topic of gamification from 2019 to 2023* has been implemented. The final step in interpretation is concluding the results of the data that has been analyzed. The bibliometric research scheme on the gamification topic is shown in Figure 1.

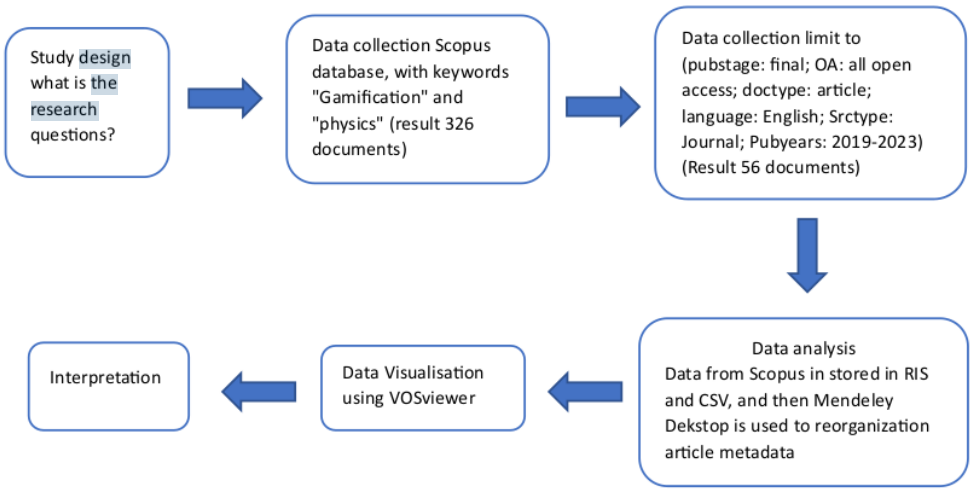

Figure 1. Bibliometric Research Scheme on the Topic of Gamification

Results and Discussion

Number of Gamification Publications from 2019 to 2023

The number of gamification publications from 2019 to 2023* is presented in Figure 2.

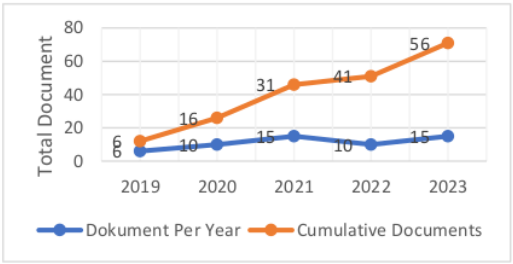

Figure 2. Publication documents from year to year on gamification

Based on Figure 2, it is found that the search results in the Scopus database yielded 56 documents on gamification from 2019 to 2023. The number of published documents shows a periodic decrease in 2022. The data for 2023 is still being updated, and the number of publications in that year is expected to increase compared to 2019, 2020, 2021, and 2022. In 2023, it is predicted that the number of published documents will increase. This is in line with research on the implementation of STEM-based physics learning (Dewi & Jauhariyah, 2021) and analysis of physics learning practices in high school to train problem-solving skills (Ayudha & Setyarsih, 2021) which also experiences an increase in the number of publications every year.

Top 5 Most Cited Authors in Research

The top five authors based on the number of citations, the results are shown in Table 1.

Table 1. Top 5 authors researching in the gamification

No	Author	Findings	Source Title	Cited by	Publisher	SJR	Quartile
1	Kalogiannakis et al., (2021)	The latest trend of gamification in science education simultaneously reveals literature gaps, challenges, obstacles, and expands possibilities for future research directions.	Education Sciences	215	MDPI AG	0.61	Q2
2	Knutas et al., (2019)	Personalized content selection based on machine learning algorithms is employed to address some of these issues and present a process for creating personalized designs that allow automation of parts of implementation.	Multimedia Tools and Applications	44	Springer New York LLC	0.71	Q1
3	Indriasari et al., (2020)	Gamification is utilized to engage students in peer review activities and to summarize empirical evidence of its effectiveness.	Education and Information Technologies	41	Springer	1.25	Q1
4	Wannapiroon & Pimdee, (2022)	When students participate in VCLE STEAM-ification learning formats, they are found to achieve higher levels of creativity and innovation compared to students learning using traditional lesson plans.	Education and Information Technologies	32	Springer	1.25	Q1
5	Pietrapertosa et al., (2021)	Improving energy efficiency in public city buildings by raising energy awareness in public schools while demonstrating the effectiveness of student involvement to promote energy savings through good behavior.	Journal of Cleaner Production	32	Elsevier Ltd	1.98	Q1

Table 1 shows that highly cited articles on gamification are dominated by Q2 quartile journals, namely Education Sciences journals. Additionally, there are journals from Q1 quartile, namely Multimedia Tools and Applications, Education and Information Technologies, and Journal of Cleaner Production.

Application of Gamification in Physics Topics

Based on the analysis of articles, several physics topics were found to incorporate gamification in their learning processes. The results are listed in Table 2.

Table 2. Application of Gamification in Physics Topics

No	Topic	Frequency	No	Topic Forndran	Frequency
1	Engines	1	11	Electromagnetism	2
2	Energy	1	12	Celestial Bodies and Planetary Systems	1

No	Topic	Frequency	No	Topic Forndran	Frequency
3	Introduction to Physics	2	13	Microfluidics and Microfabrication	1
4	Laboratory	3	14	Fundamental Particles and Forces of Nature	1
5	Electric Resistors	1	15	Circuit Laws	1
6	Waves and Vibrations	1	16	Waves and Optics	1
7	Radiation	1	17	Science Concepts	2
8	Motion Concepts	2	18	Biophysics	1
9	Light	1	19	Educational Robotics	2
10	Wheel Spinning	1	20	Not Specified	30

Based on Table 2, there are still many physics topics that have not been connected to gamification. This is an opportunity for further research. Some research shows, gamified learning increases student motivation and has a positive effect on the introductory physics lecture process (Martinez et al., 2023). Gamification is a methodology that is able to attract and delight students in the teaching material of electrical resistors (Forndran & Zacharias, 2019).

Implementation of Gamification in Research Types

Based on the analysis of the article, several research types were used in the implementation of gamification in the learning process. The results are presented in Table 3.

Table 3. Implementation of Gamification in Research Types

No	Research Subject	Frequency
1	Experiments	16
2	Descriptive	5
3	Literature Review	4
4	Research and Development (R&D)	2
5	Qualitative Descriptive	1
6	Quantitative Descriptive	1
7	Ethnography	1
8	Unspecified	26

Table 3 provides information that most of the use of gamification in physics learning uses experimental research methods, such as the application of the Gamified Flipped Learning method has a positive impact on students' innovation skills in a virtual physics laboratory course (Ahmed & Asiksoy, 2021). Apart from that, there is also R&D, Literature review (Kalogiannakis et al, 2021), qualitative descriptive (Pardo-Baldoví et al, 2023), ethnographic study (Yetişkin et al., (2022), etc. This shows that applying gamification in physics learning can use various research methods.

Implementation of Gamification in Research Subjects

Based on the analysis of the article, several research subjects were used in the implementation of gamification. The results are presented in Table 4.

Table 4. Implementation of gamification in Research Subjects

No	Research Type	Frequency
1	University	8
2	Elementary School	6
3	Junior High School	3
4	High School	3
5	Research Papers	1
6	Unspecified	35

Table 4 shows that gamification in physics learning is more widely applied at the university level (Gómez-Espina et al., 2019; Martinez et al., (2023). Apart from that, it is also applied at the high school level (Kiemeneij et al., (2023); Anh et al., (2021), junior high school (Cheng et al., 2021; Heliawati et al., 2022), and elementary school (Zourmpakis et al., 2023; Ramli et al., 2021). This can be used as a reference for future researchers in choosing the subject or level of education used.

Keywords Associated with Gamification

The results of primary publications and research interests based on author keywords in co-occurrence analysis are presented in Figure 3.

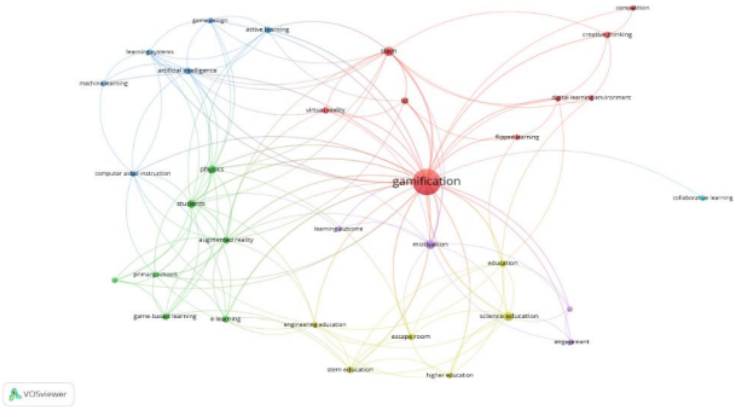

Figure 3. Network visualization gamification in physics learning

The VOSviewer provides mapping of bibliometric analysis with three different visualizations, namely the network visualization listed in Figure 3. This visualization was obtained with the help of VOSviewer software by extracting 56 articles based on article titles, keywords, and abstracts. There are 33 items identified from 6 clusters, marked with different colors such as red, green, blue, yellow, purple, and light blue. Each cluster indicates the development of gamification research in physics education, which can be observed in Table 5.

Table 5. Research development of each cluster

No	Cluster	Number of Items	Keywords
1	Red	9	Competition, creative thinking, digital learning environment, flipped learning, gamification, ict, innovation skills, stem, visual reality
2	Green	7	Augmented reality, e-learning, game-based learning, physics, primary schools, secondary schools, students
3	Blue	6	Active learning, artificial intelligence, computer aided instruction, game design, learning systems, machine learning
4	Yellow	6	Education, engineering education, escape room, higher education, science education, stem education
5	Purple	4	Engagement, learning outcome, motivation, systematic literature review
6	Light blue	1	Collaborative learning

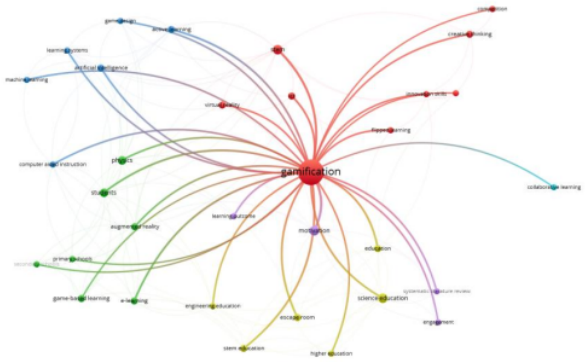

Figure 4. Network visualization gamification in physics learning

Based on Figure 4, in gamification research, it is linked with the red cluster, namely virtual reality in gamification can improve student reasoning performance in the LMS platform (Verawati et al., 2023). The application of gamification methods in STEM activity-based learning significantly improves student learning outcomes (Mahendra et al., 2023). The Gamified Flipped Learning method in virtual physics laboratory courses has a positive impact on students' innovation skills (Ahmed & Asiksoy, 2021).

Apart from the red cluster, gamification is linked with the green cluster, Namely gamification in e-learning Global warming material presented in the form of adventure game boards can help produce more interesting e-learning for students (Desiana et al., 2023). Gamification integrated with augmented reality technology is able to increase students' learning interest in kinematics material (Simaremare et al., 2022). Gamification is linked with the blue cluster, Namely the use of gamification in active learning makes the learning process more interesting, fun and effective (Jusuf, 2016). Gamification is a game design to support the learning process (Satriyo & Anistyasari, 2020).

The purple cluster is also linked to gamification, such as Gamification must have the right concept and clear goals and be able to build engagement for students in learning so that learning is more fun (Srimuliyani, 2023). Gamification is also linked with the yellow cluster, Namely gamification can provide solutions for the world of education (Haryani et al., 2023). Gamification is more focused on the implementation of science education (Badryatusyahryah et al., 2022). Lastly, gamification is also linked with the light blue cluster such as Gamification is used to practice student collaboration with other students and fellow group members (Rahma et al., 2023).

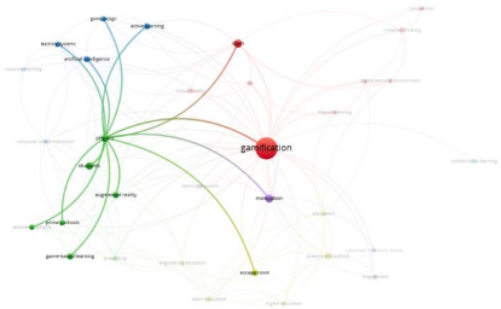

Figure 5. Network visualization physics

Based on Figure 5, in physics research, it is linked with the red cluster, Namely interesting gamification can make students not easily bored with physics learning (Laeli et al., 2022). Apart from the red cluster, physics is linked with the green cluster, namely Gamification integrated with augmented reality technology can increase students' interest in learning physics (Simaremare et al., 2022). Physics is linked with the blue cluster, Namely the use of gamification in active learning makes the learning process more interesting, fun and effective (Jusuf, 2016). The purple cluster is also linked with physics such as Gamification in physics learning can increase motivation (Amalia et al., 2024). Lastly, physics is linked with the yellow cluster, namely escape room (Lathwesen & Belova, 2021; Vörös & Sárközi, 2017).

The results of the gamification overlay visualization in physics learning are shown in Figure 6.

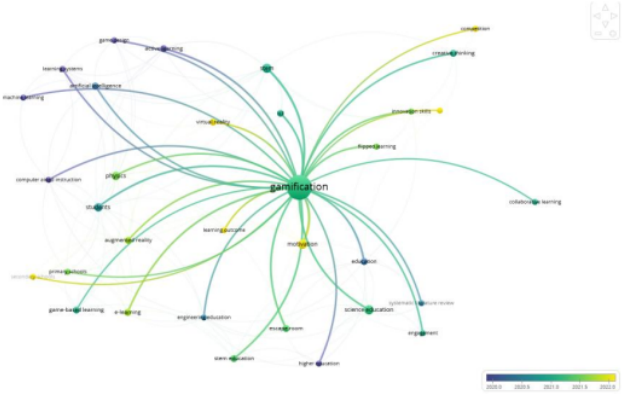

Figure 6. Overlay visualization gamification in physics learning

Based on

Figure 6, overlay visualization penelitian gamifikasi di dua tahun terakhir lebih banyak dihubungkan dengan motivation, secondary schools, virtual reality, learning outcome, competition. Gamification in physics learning can increase motivation (Amalia et al., 2024) and student learning outcomes (Arlen et al., 2020). Gamification combined with virtual reality can help students to visualize practicum material, so as to support the success of practicum (Siahaan et al., 2021). The application of gamification in the form of competition can create a competitive environment in an effort to improve student learning outcomes (Badryatusyahryah et al., 2022). Gamification can also be applied to secondary schools that produce 2D animation learning media in physics subjects (Wahyuni et al., 2021).

Conclusion

Research on gamification in physics learning is evolving every year. Six clusters are visible when the trend of gamification research in physics learning from 2019-2023 is visualized. The findings of this research can assist academics in understanding the global trends in gamification research in physics learning and provide guidance for future research. This analysis offers a good starting point for future gamification research in physics learning. The limitation of this research lies in the data collection, which only comes from the Scopus database published in the last 5 years, from 2019 to 2023. Therefore, it is expected for future researchers to expand the data collection and publication years, not just from the Scopus database.

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