JPPIPA 11(12) (2025)

Jurnal Penelitian Pendidikan IPA

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Game-Based Learning for Improving Students' Creative Thinking Skills in Science Learning: A Systematic Literature Review

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Received: July 04, 2025
Revised: November 27, 2025
Accepted: December 27, 2025
Published: December 31, 2025

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DOI: 10.29303/jppipa.v11i12.12014

Abstract: Science learning must be able to improve creative thinking skills to face the challenges of knowledge and technology development. This study aims to explore game-based learning models related to research trends, research designs used, fields of study that apply them, their influence on learning outcomes, and profiles of the use of game-based learning in science learning at various levels of education. This study is a Systematic Literature Review (SLR) with the PRISMA method to collect, analyze, and compile findings regarding game-based learning models in learning. This study is limited to articles obtained from the Publish or Perish search engine, from two databases, namely, Google Scholar and Crossref. The results of the literature review of 29 articles that met the inclusion criteria illustrate that game-based learning models make it easier for students to solve complex problems quickly, accurately, and efficiently using an innovative approach through a fun and challenging learning experience. The results of the literature review show that in the period 2020–2025, research on the application of game-based learning mostly uses the Research and Development method with the ADDIE model. The application of game-based learning in the field of science subjects is still very limited, namely only 14%, while the dominant application is in the field of mathematics. Game-based learning has a positive impact on students' cognitive, affective, and psychomotor learning outcomes, critical thinking skills, creativity, understanding of material, reading skills, learning motivation, science literacy, learning interest, physical activity, practical experience in dealing with emergencies, and building cooperation, communication, empathy, and social interaction. Game-based learning models can improve the quality of science learning.

Keywords: Creative thinking; Critical thinking; Game-based learning; Science learning

Introduction

The development of science and technology requires a person to be able to access, understand, and master information and knowledge effectively. To face these challenges, a person not only needs to access information but also must be able to think critically, systematically, logically, and creatively (Siregar et al., 2020). Therefore, the ability to obtain, select, and process information through a deeper thinking process is needed. One of the educational programs that can help develop these skills is education that is oriented towards improving critical, systematic, logical, and creative thinking skills.

Skills are thinking skills that are classified as high-level thinking or Higher Order Thinking Skills (HOTS)

How to Cite:
Kurniarta, I. A., Redhana, I. W., & Tika, I. N. (2025). Game-Based Learning for Improving Students' Creative Thinking Skills in Science Learning: A Systematic Literature Review. *Jurnal Penelitian Pendidikan IPA*, *11*(12), 22–32. https://doi.org/10.29303/jppipa.v11i12.12014

(Anditiasari et al., 2021; Faturohman & Afriansyah, 2020). These creative thinking skills must be able to produce new, more perfect concepts and thoughts in order to determine various alternative ideas to solve a problem according to the available data or information. This is in line with research from Anditiasari et al. (2021), where creative thinking skills are students' abilities to convey new ideas and thoughts that have never been conceived by others before. Student learning creativity can be measured based on five indicators, namely fluency, flexibility, originality, elaboration, and evaluation. Fluency is the ability of students to raise many questions, flexibility is the ability of students to come up with solutions from different perspectives, originality is the ability of students to come up with ideas they have, elaboration is the ability of students to detail the details of an object, idea, or situation, and evaluation is the ability to make decisions in open situations (Agustiana et al., 2020). Therefore, student creativity has an important role in solving a problem faced (Ernawati et al., 2019).

In reality, student creativity still needs to be improved. This is in line with observations made by Maulidyah et al. (2024) that low student creativity in the learning process is caused by the use of conventional learning methods that are less effective in encouraging students to think creatively in solving problems independently. In addition, low encouragement from parents, lack of student imagination, lack of use of interactive learning media and the use of learning models that do not involve students also cause low student learning creativity (Mashitoh et al., 2021; Maulidyah et al., 2024). On the other hand, differences in students' abilities in understanding science material are often ignored, causing gaps in the learning process (Meganita et al., 2022). In addition, the learning model applied by most teachers still tends to be monotonous, providing fewer opportunities for students to explore concepts in depth and develop student creativity (Apriliyanti et al., 2022).

To develop students' low creativity, various methods have been carried out by science teachers in schools, one of which is by implementing game-based learning. Game-based learning is an effective strategy because this method is able to build a pleasant, relaxed, but serious atmosphere without ignoring learning objectives, so that it can overcome student boredom and increase motivation in learning (Zuhriyah, 2020). Game-based learning is also very effective in stimulating thinking skills, training concentration, enthusiasm for learning, and generating positive competition between students (Isnaini & Huda, 2020). According to Wahyuni et al. (2024), game-based learning is a learning method that delivers material through fun activities so that it can support the development of students' cognitive, affective and psychomotor aspects. Not only training students' creativity, game-based learning can also stimulate teachers' creativity in managing learning and designing innovative learning media (Pratiwi & Hardini, 2022).

Game-based learning has been proven to be effective in various subjects and levels of education because it can increase students' creativity through various types of interesting and fun games. In sports subjects, game-based learning is used in teaching passing skills, and understanding passing movements from the initial, core and final phases as well as developing game principles and fostering learning motivation (Amin et al., 2021; Rahmadani et al., 2021; Santos & Hudain, 2020). In Arabic subjects, game-based learning can help students improve their vocabulary mastery, reading skills, writing skills and sentence writing skills (Iqbal & Suriningsih, 2021; Rahmiati et al., 2022). At the elementary level, game-based learning is very popular for mathematics subjects. Game-based learning helps students understand the concepts of subtraction, multiplication, division, measurement, and geometric shapes that are considered abstract (Halidah et al., 2024; Rafiah et al., 2023; Syarifuddin et al., 2023). In secondary schools, game-based learning is used in science learning to teach the concept of momentum by playing marbles, and to teach the laws of physics with the lato-lato game, which improves critical thinking skills and student engagement (Hasan et al., 2024). In high schools, game-based learning is applied in physics subjects to enhance understanding of the concepts of work and energy, which are often difficult to understand and cause misconceptions, by providing learning video assistance to improve learning outcomes and encourage student creativity (Yelensi et al., 2020). The flexibility of game-based learning in various subjects and levels of education shows its effectiveness in improving creativity to prepare students to face complex global problems.

Literature study research on the effect of game-based learning on creative thinking skills has been widely conducted in mathematics subjects (Prasetya et al., 2025). However, research on the effect of game-based learning on students' creative thinking skills in Science Learning has never been conducted by previous researchers. This research is important because game-based learning is one of the learning strategies that can motivate students to be more active and participate in the learning process (Za et al., 2024).

Based on the explanation above, the problem formulation to be answered through this research is: What is the tendency of research that applies game-based learning in learning?; What are the research

designs that use game-based learning in learning?; What are the subjects that use game-based learning in learning?; What are the learning outcomes achieved after using game-based learning?; Does game-based learning affect students' creative thinking skills?; and What is the profile of the application of game-based learning strategies at various levels of education?

Method

In this study, the method used to select and screen articles on the influence of game-based learning on creative thinking skills in learning is the PRISMA (*Preferred Reporting Items for Systematic Reviews and Meta-Analyses*) method. The procedures carried out are shown in Figure 1. The initial stage carried out was to identify research needs and formulate clear objectives to determine the impact of game-based learning on students' creative thinking skills in learning. The main keywords used in the article search were "*game-based* learning", "creative thinking", "games", and "creative thinking skills".

With the help of the Publish or Perish article search engine, data were collected from two databases, namely Google Scholar and Crossref. The data collected were in the form of Sinta-accredited journal articles published from 2020 to 2025, and continued with a selection stage with inclusion and exclusion criteria. Inclusion criteria included articles on the application of game-based learning in science learning, articles discussing the application of game-based learning at elementary, middle, and high school levels, published from 2020 to 2025, using Indonesian or English, indexed by Scopus, Sinta 1, Sinta 2, Sinta 3, and Sinta 4, and publication of journal articles not in the form of papers or conferences. For journal articles outside these criteria, they are automatically not used. The selection stage that was carried out begins with the title screening stage, the articles used are articles that include the title of game-based learning or games in learning both in English and Indonesian, followed by the next stage, namely reading the abstract, the articles used are articles that in their abstracts explain the application of game-based learning that uses qualitative, quantitative methods, and development research and is carried out at elementary and secondary education levels, for articles that do not include this are not used.

Articles that pass the selection are reviewed further to ensure that the articles used meet the inclusion criteria that have been set. The final stage is reporting the results of the analysis, which are presented in the form of systematic tables and/or graphs to facilitate interpretation of the data obtained. The stages of article selection are illustrated with a PRISMA diagram that includes the number of articles found in the initial stage, the number of articles that did not pass the selection in the screening process, and the number of articles that were analyzed entirely and used in this study. This process produces a comprehensive report on the impact of the application of game-based learning on students' creative thinking skills in science learning. This method ensures that the systematic review is carried out in a structured, transparent, and accountable manner.

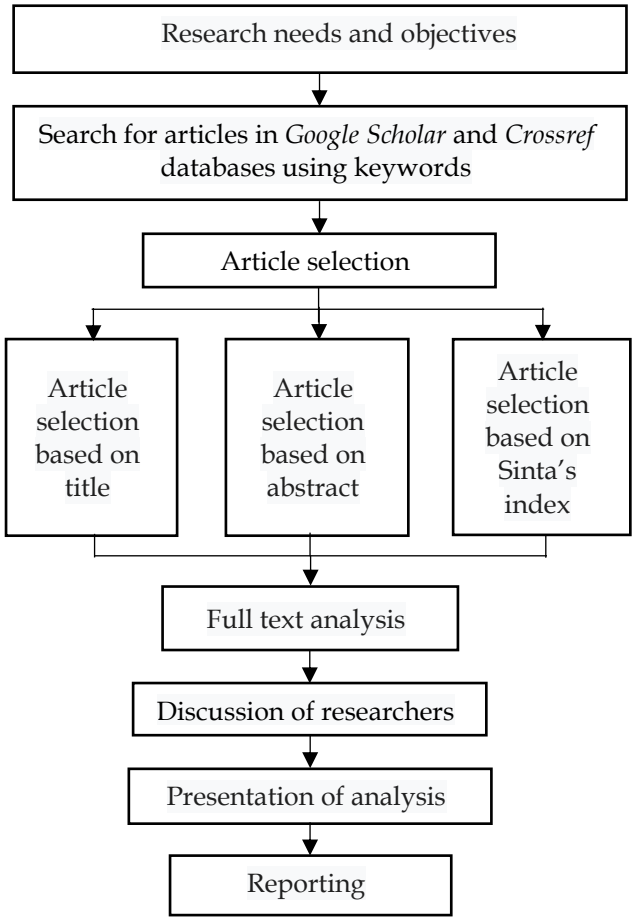

Figure 1. Data collection, analysis, and reporting procedures

Results and Discussion

This literature review aims to provide information related to research trends that apply game-based learning in learning, research designs that use game-based learning in learning, and profiles of the application of game-based learning in education. Thus, this information can be a reference or baseline reference for researchers to develop innovative and interactive learning.

Articles were searched from Google Scholar and Crossref databases. This search resulted in 1100 articles. Then, identification was carried out to find the same articles, and 185 similar articles were obtained. A total of

915 articles that did not have similarities were then reviewed based on their titles. The title criteria used to select articles were article titles containing game-based learning in learning, articles written in Indonesian and English, articles from journals, and articles that only came from research results. This screening process resulted in 436 articles that met the requirements, while those that did not meet the criteria were 479, consisting of 293 articles that had nothing to do with game-based learning models in learning, 86 articles that did not use Indonesian or English, 34 in book form, and 66 articles using the literature review method. The screening process was continued by reading the abstract. The selection of articles was based on several criteria, namely the article could be accessed for free (open access), the article explains the influence of game-based learning on learning, the article contains qualitative, quantitative, and research and development research methods, and the screening process resulted in 29 articles that were appropriate and 407 articles that did not meet the criteria. The 407 articles that did not meet the criteria consisted of 98 inaccessible articles, 175 articles that did not explain the research methods used, and 134 articles that were not applied to elementary and secondary education levels. After a long screening process, 29 articles were obtained, which were then reviewed further. The entire identification and screening process is explained in detail in Figure 2.

A total of 29 articles selected in the initial stage of the selection process were reviewed in depth by both researchers simultaneously. This review process was carried out carefully to ensure that each article met the predetermined inclusion criteria and was relevant to the focus of the research. If there were differences of opinion or review results between the two researchers, intensive discussions were conducted to align perceptions and reach a standard agreement. This collaborative approach aims to minimize subjectivity, increase the validity of the review results, and ensure that each selected article makes a significant contribution to the analysis of findings and research. Thus, this review process prioritizes not only caution but also academic integrity in the preparation of the SLR. The results of the review can be presented in the following paragraphs.

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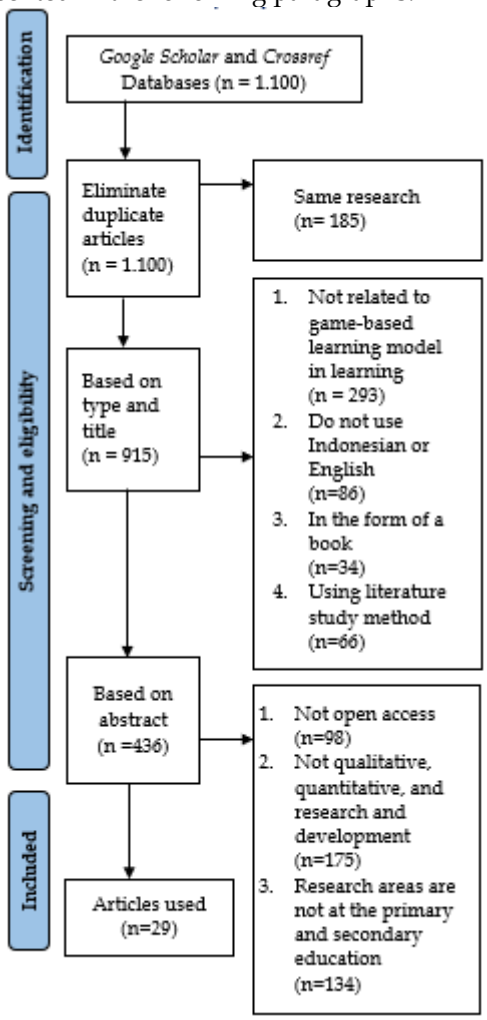

Figure 2. PRISMA Diagram

In the last five years, game-based learning models have had a significant impact on improving students' creative thinking skills. This model makes it easier for students to solve complex problems with an innovative approach through a fun and challenging learning experience. With games, it can hone students' mentality and personality to be more careful and persistent, so as to hone thinking skills in making fast, precise, and efficient decisions (Pahri et al., 2023). With this learning model, it provides students with the opportunity to construct their knowledge independently and find targeted problem-solving (Darmawan et al., 2021). In addition to encouraging cognitive skills, game-based learning models also encourage students' metacognitive abilities, such as innovation, cooperation, and analytical skills that allow students to be creative in solving

problems (Putra et al., 2024). Not only does it have an impact on cognitive and metacognitive aspects, but game-based learning also contributes to the development of social skills, which are the main skills for individuals to adapt in the community environment. In general, game-based learning creates innovative, fun, and stress-free learning, thereby fostering togetherness, caring, self-control,, and positive social interactions (Wahyuni et al., 2024).

The results of the literature review conducted show that the application of game-based learning in research can be seen in Figure 3. The figure presents data on the number of publications discussing the use of this model in the last five years.

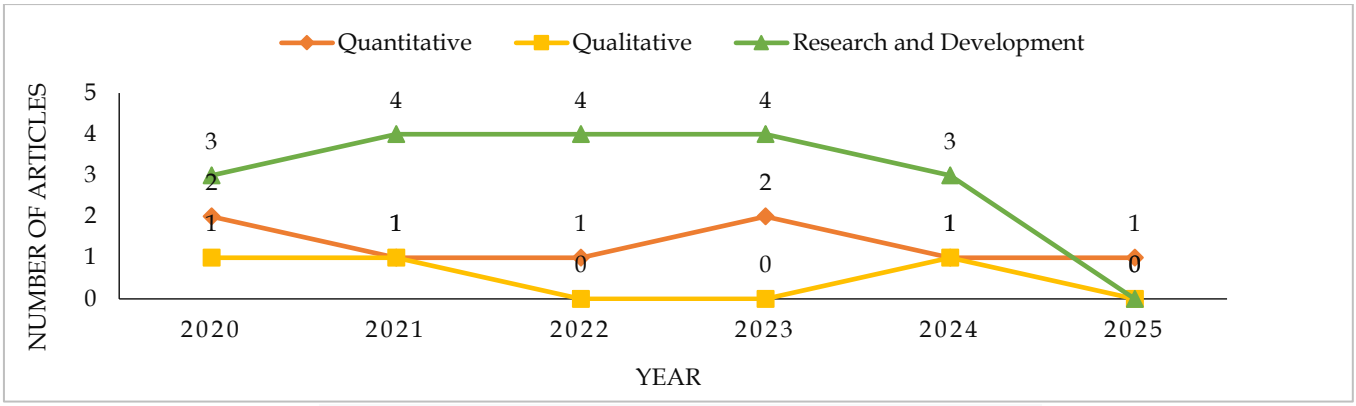

Figure 3. Trends in the use of game-based learning from 2020 – 2025

Figure 3 shows the research method that uses game-based learning models in the last five years of learning. The use of the research and development method increased in 2021–2023 but decreased in 2024–2025. Meanwhile, the use of qualitative methods is not widely used, so there is no significant increase. Quantitative methods increased in 2023 but decreased again in 2024 and remained stagnant until 2025.

The results of the literature review revealed that various research methods were used to test the impact of game-based learning models on learning outcomes. Details of research methods using game-based learning models are shown in Table 1. Based on the table, research and development is the most dominant method used in related studies. This is reflected in the percentage of development research in the last five years, which reached 62%. Various development models were applied in this study, namely, ADDIE, Borg and Gall, 4D, and Hannafin and Peck. The most widely used development model is the ADDIE development model. This model is considered to have systematic and flexible stages so that it makes it easier for researchers to design, develop, and evaluate learning products.

Table 1. Use of Research Methods

Research methods	Number of Articles	Percentage (%)
Quantitative	8	28
Qualitative	3	10
Research and Development	18	62

Most studies show the use of game-based learning models applied in various subject areas. This model is used to help students achieve targeted competencies. Some dominant subject areas that utilize game-based learning models in the learning process are shown in Figure 4.

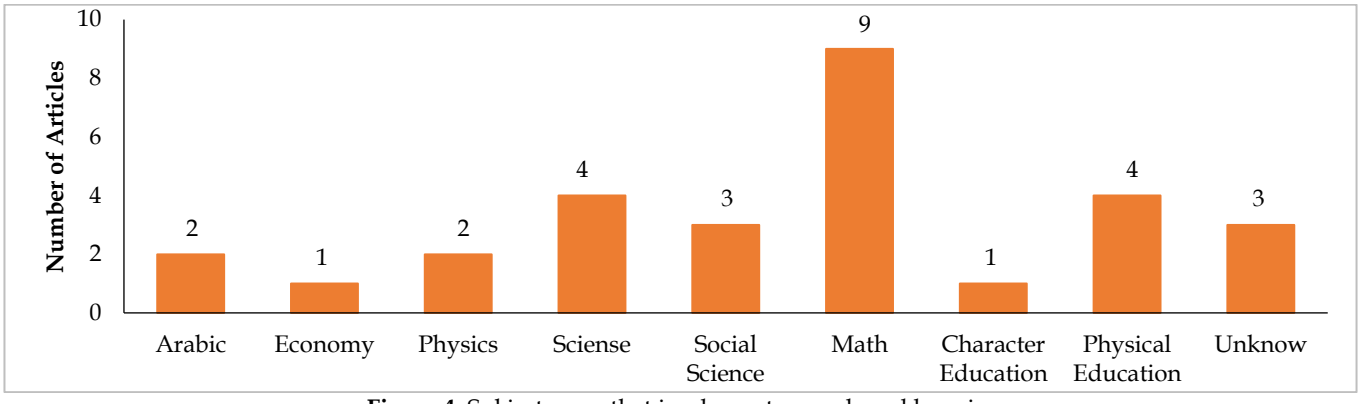

Figure 4. Subject areas that implement game-based learning

Subject areas that implement game-based learning models as a strategy to achieve learning objectives include Physical Education (14%) (Amin et al., 2021; Darmawan et al., 2021; Julianur et al., 2020; Putra et al., 2024) Character Education (3%) (Fitria & Nugrahanta, 2023) Mathematics (31%) (Darmawan et al., 2021; Desyawati et al., 2021; Dewi et al., 2022; Halidah et al., 2024; Nurussofa & Astuti, 2023; Saputra & Hakim, 2024; Syarifuddin et al., 2023; Ulhusna et al., 2020; Varadita et al., 2025) Social Sciences (10%) (Anggraini & Kristin, 2022; Fauziyati & Sriyanto, 2025; Pahri et al., 2023), Sciences (14%) (Hikmah et al., 2023; Mardianti et al., 2022; Pratiwi & Hardini, 2022; Rahmadani et al., 2023), Physics (7%) (Hasan et al., 2024; Yelensi et al., 2020), Economics (3%) (Sitorus & Santoso, 2020), Arabic (7%) (Isnaini & Huda, 2020; Rahmiati et al., 2022). Meanwhile, as many as 10% of articles that use game-based learning models in learning do not mention the subject area.

Based on Figure 4, the application of game-based learning in the field of science is still limited, as seen from the results of the review, which found only four articles (14%) of the total 29 articles found. The field of science is very suitable for implementing this model because it can develop students' science process skills, such as observing, predicting, classifying, and evaluating (Pratiwi & Hardini, 2022). In addition, this approach helps students develop 21st-century skills, namely critical and creative thinking. With challenge-based games, students are indirectly encouraged toward the development of their thinking skills. The field of study that uses the most game-based learning models is mathematics. Mathematics learning is often considered a scary and challenging subject with formulas that cause boredom (Halidah et al., 2024). By utilizing a game-based approach, it can change the learning atmosphere to be interactive and fun, helping students understand abstract concepts, increase learning motivation**,** and develop critical thinking and problem-solving skills.

The application of game-based learning models has weaknesses that must be considered, such as requiring a long process and time in preparing learning, and creating a noisy and less conducive classroom atmosphere (Halidah et al., 2024). However, the application of game-based learning in the fields of Physical Education, Social Studies, Physics, Economics, Arabic, and Character Education shows a significant influence on the achievement of learning outcomes. Game-based learning models can help students increase motivation, active student involvement, and understanding of concepts (Rahmadani et al., 2023). In addition to the cognitive aspect, this approach can also improve students' social skills and character through an active and enjoyable learning atmosphere.

The application of game-based learning in learning has a positive impact on student learning outcomes. Learning outcomes influenced by the application of game-based learning can be seen in Figure 5.

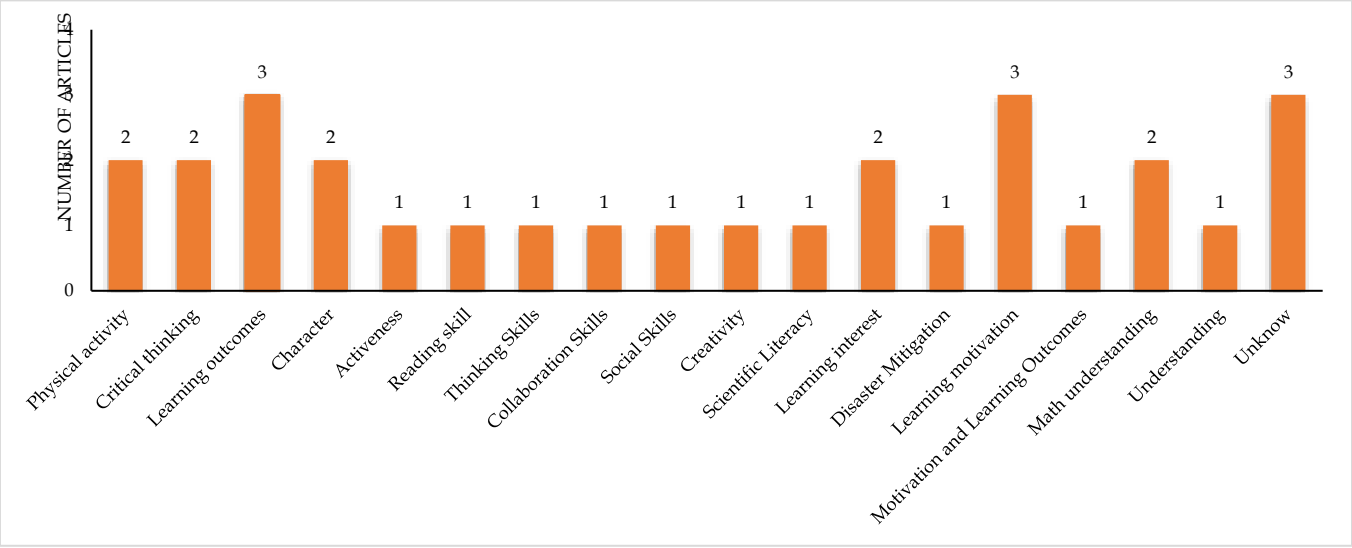

Figure 5. Learning outcomes achieved after implementing game-based learning

Game-based learning has a direct influence on the cognitive, affective, and psychomotor domains. Through direct involvement and structured games, students are not only trained to think critically, but also to improve creativity, mathematical understanding, reading skills, learning motivation, scientific literacy, learning interest, physical activity, gain practical experience in dealing with emergency situations, and build cooperation, communication, empathy, and social interaction. This model not only improves conceptual understanding but also improves 21st-century skills

such as critical thinking skills, creativity, collaboration, and communication skills (Baharizqi et al., 2023).

The application of game-based learning in science learning helps students solve various problems, be active in expressing opinions, be enthusiastic in the learning process, and improve cooperation (Rahmadani et al., 2023). According to Mardianti et al. (2022), challenges, clear goals, interesting assessments, and constructive feedback have a significant influence on problem-solving skills, which will later form creative, superior, and independent students so that they are able to compete in real life (Hikmah et al., 2023). In other words, game-based learning can stimulate sensory performance, balance cognitive and affective aspects, develop thinking skills, and improve students' creative and critical thinking skills.

Viewed from the affective domain, game-based learning increases motivation and forms creative characters (Mardianti et al., 2022; Pratiwi & Hardini, 2022). Students' learning motivation increases because in the learning process students are involved in playing activities, so that the learning atmosphere is more enjoyable. In addition, with games, students are invited to find solutions to problems openly, so that they are required to produce new ideas that are original. In the cognitive domain, game-based learning improves understanding of the material, scientific literacy, and learning outcomes (Anggraini & Kristin, 2022; Hasan et al., 2024; Saputra & Hakim, 2024). In learning, students' attention will be focused so that the subject matter will be easy to understand. This approach also encourages the creation of positive interactions between teachers and students, and repetition in the game strengthens understanding of the concepts presented.

At the level of education, game-based learning can be applied at the elementary and secondary education levels. Based on Figure 6, the application of game-based learning in science learning can improve creative thinking skills in Elementary Schools with the largest percentage of 69%, while in Junior High Schools it is 17% and the lowest is at the Senior High School level of 13%.

Game-based learning is very suitable to be applied at the elementary school level because at this stage, students are still in the concrete operational phase according to Piaget's theory (Imanulhaq & Ichsan, 2022; Setiadi, 2021). Students at this stage learn through direct experience, exploration, and fun activities with real objects (Sanjaya et al., 2024). Games are the right means to understand basic concepts contextually and meaningfully. Game-based learning has a positive influence on various learning outcomes such as learning outcomes, motivation, critical thinking skills, understanding of material, creativity, character, collaboration and physical activity (Anggraini & Kristin, 2022; Azizah & Safira, 2021; Darmawan et al., 2021; Desyawati et al., 2021; Dewi et al., 2022; Fauziyati & Sriyanto, 2025; Fitria & Nugrahanta, 2023; Halidah et al., 2024; Hikmah et al., 2023; Istiningsih et al., 2021; Julianur et al., 2020; Nurussofa & Astuti, 2023; Pahri et al., 2023; Pratiwi & Hardini, 2022; Rahmadani et al., 2023; Santos & Hudain, 2020; Syarifuddin et al., 2023; Ulhusna et al., 2020; Wahyuni et al., 2024). At the junior high school level, game-based learning is still relevant, although it must be adjusted to contextual and interesting learning. Subjects that have used game-based learning models at the junior high school level are Arabic, PJOK, Mathematics and Physics (Hasan et al., 2024; Isnaini & Huda, 2020; Putra et al., 2024; Rahmiati et al., 2022; Varadita et al., 2025). Game-based learning has not been widely applied in various subjects at the junior high school level, even though at the junior high school level, game-based learning is still relevant for strengthening creative thinking skills. This is because game-based learning provides space for interaction, increases self-confidence, and supports critical reasoning for proper decision making (Azmi et al., 2025).

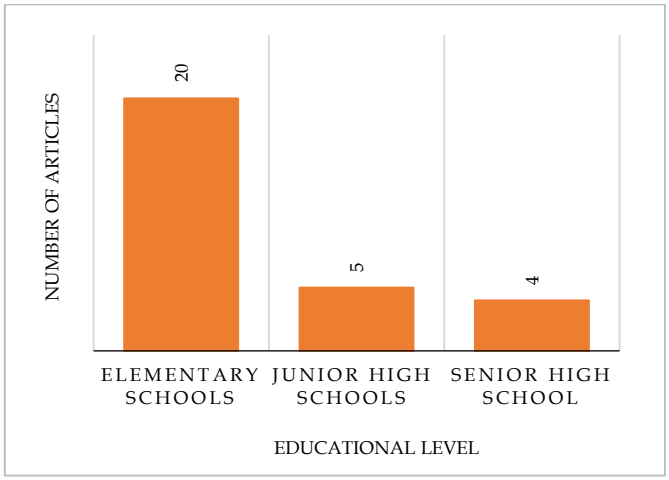

Figure 6. The implementation of game-based learning at educational levels

The results of Figure 6 show that the application of game-based learning is least applied at the high school level. High school students are generally at the formal thinking stage; they can think abstractly, logically, and analytically (Handayani & Assidik, 2025). However, game-based learning can still be applied in high school as long as it is packaged in a more complex form, such as simulation, problem-based games, or projects, so as to increase student motivation and involvement in learning.

Conclusion

Game-based learning has a positive impact on students' creative thinking skills. The results of the literature review illustrate that the game-based learning model makes it easier for students to solve complex problems with an innovative approach through a fun and challenging learning experience. With games, students' mental strength and personality can be honed to be more careful and persistent, honing thinking skills in making quick, precise, and efficient decisions. In the 2020–2025 period, research on game-based learning mostly used the development method with the ADDIE development model. The application of game-based learning in the field of science is still limited, with only four articles (14%) of the total 29 articles found, and all of them were applied at the elementary school level. Meanwhile, at the junior high school level, none were found, so this condition shows that there are great opportunities and potential for further research at this level. The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section. The subject area that most utilizes this model is mathematics, which is considered difficult and scary due to abstract concepts. Game-based learning has a positive impact on students' cognitive, affective, and psychomotor learning outcomes, critical thinking skills, creativity, understanding of the material, reading ability, learning motivation, science literacy, learning interest, physical activity, practical experience in dealing with emergencies, and building cooperation, communication, empathy, and social interaction. The findings of this review suggest that educators and researchers need to consistently integrate game-based learning in the implementation of science learning to improve the quality of learning.

Acknowledgments
The authors would like to express their highest thanks to Jurnal Penelitian Pendidikan IPA for publishing this article.

Author Contributions
I M. A. K. searched for articles, analyzed the data, and wrote the manuscript; I N. T. reviewed the manuscript; I W. R. reviewed and submitted the manuscript. All authors have read and approved the published version of the manuscript.

Funding
This research received no external funding

Conflicts of Interest
The author declares no conflict of interest in writing the article.

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