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THE USE OF GAME-BASED LEARNING MEDIA TO SUPPORT STUDENTS' COGNITIVE ABILITIES IN MATHEMATICS

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ABSTRACT

Cognitive abilities are very important for students to have because they are related to the thinking process. However, students' cognitive abilities in Indonesia are relatively low, so efforts are needed to develop students' cognitive abilities. Currently, games have become a popular activity for children. Games designed specifically for learning mathematics have the potential to help students understand abstract mathematical material. The purpose of this study is to conduct a literature review on the use of games-based learning media to support students' cognitive abilities in mathematics learning. The research method used is a systematic literature review. The stages are research question, data selection and extraction, and data analysis. Data was obtained by collecting all articles related to the research topic. Articles are taken from Google Scholar and Springer Link databases. From a total of 1836 articles obtained from the two databases, 15 articles were selected based on quality assessment criteria for analysis. The results of the research are that the use of games-based learning media in mathematics learning has various positive impacts on students' cognitive abilities. Games-based learning media can improve numeracy skills, mathematical communication, mathematical representation, and higher-level thinking. This research can become literature for researchers who will develop games-based learning to support students' cognitive abilities.

Keywords: Game-Based Learning, Mathematics, Cognitive Ability

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PRELIMINARY

Mathematics is a science that plays an important role in human life. Mathematics is useful for honing a person's thinking abilities. Mathematics discusses logical reasoning in studying relationship patterns, thinking patterns, art and language so that it makes it easier for someone to think (Khoirunnisya, 2021). Therefore, mathematics can improve students' cognitive abilities such as critical thinking, problem-solving, reasoning, and creative thinking. Cognitive abilities are very important for students to have because they relate to the thinking process of gaining knowledge and using it to solve problems and adapt to the environment (Naufal, 2021).

The important role of mathematics in improving students' cognitive abilities causes mathematics to become a mandatory subject at every level of education. However, the fact

that occurs is that students' cognitive abilities are relatively low. Based on assessments carried out by the Program for International Student Assessment (PISA), Indonesia received a score far below the average. In 2018, the score in mathematics obtained by Indonesia was 379 out of an average of 489. The Trends in International Mathematics and Science Study (TIMSS) also reported that mastery of mathematics by Indonesian junior high school students was still low. In 2021, Indonesia was ranked 44th out of 49 countries with a score of 397.

The conditions shown in the PISA and TIMSS assessments show that the cognitive abilities of students in Indonesia in the field of mathematics are relatively low. Students have difficulty thinking mathematically to carry out reasoning in solving problems. Low cognitive abilities make it difficult for students to face future challenges. Students have difficulty solving problems in everyday life in an era of technological development because students' reasoning, argumentation, and creative abilities are underdeveloped (Tabun et al., 2020). Therefore, efforts are needed to help students learn mathematics.

One way to help students understand mathematics concepts is to use learning media. In learning mathematics, media is an essential component because it can change abstract material in mathematics to be more concrete. Therefore, media needs to be chosen carefully to support successful learning. Choosing good learning media certainly requires paying attention to student character so that learning objectives can be achieved (Purmadi et al., 2018).

In this era, games have become an activity that is very popular with children. Based on observations, researchers found that many students were not focused during mathematics learning activities. Some students even played games when the teacher was explaining in front of the class. Apart from that, during break times students often spend more time playing digital games. This is supported by the results of the *Survei Penetrasi dan Perilaku Internet* 2023 by *Asosiasi Penyelenggara Jasa Internet Indonesia* (APJII) which reported that 32.29% of Indonesians use the internet to play online games via mobile internet and 2.71% via fixed broadband. As many as 42.23% of people spend more than 4 hours playing. Therefore, for playing games to become something of value, games need to be developed into media that can be used in learning activities without ignoring the essential values, attractiveness, and effectiveness of the game (Qohar et al., 2019).

In mathematics learning, games must be specially designed to give students tasks to find mathematical relationships. These tasks make games an effective medium for improving students' mathematical reasoning abilities (Jensen & Skott, 2022). According to

Pho & Dinscore (2015), games can also evaluate critical thinking and problem-solving abilities. Besides improving thinking skills, games also provide opportunities for students to gain different experiences and perspectives on learning mathematics. Games can increase students' learning motivation, build an interactive learning environment, and improve students' understanding of mathematics (Rofiqoh et al., 2020; Saputro et al., 2018).

Based on the description above, games have a positive impact on students' cognitive and non-cognitive abilities in mathematics learning. In the last decade, there has been a lot of research examining the effectiveness of games in learning mathematics. Therefore, researchers conducted a literature review regarding the use of games to support students' cognitive abilities in learning mathematics. A literature review related to the use of games in mathematics learning has been carried out by Hasanah et al. (2021). However, this research only discusses its effect on student learning outcomes. This research has not discussed the influence of game-based learning media on students' cognitive abilities. Therefore, this research aims to describe the impact of using games on students' cognitive abilities, types of games, objectives, and types of research that are most often used by other researchers on the topic of using games-based learning media to support students' cognitive abilities in mathematics learning. This research can become literature and consideration for researchers who will develop games-based learning to support students' mathematical cognitive abilities.

METHODS

This research uses a Systematic Literature Review (SLR) method. SLR is used to identify, review, evaluate, and interpret all available research with relevant topics and research questions (Hasanah et al., 2021). SLR can help researchers develop a framework of thinking under theories, findings, or previous research results. The articles used in this research came from the Google Scholar and Springer Link databases. There are 3 steps in this research, namely planning, data selection and extraction, and data analysis.

Research Questions

In this step the researcher identifies, creates research questions, and provides an objective review. The research question (RQ) in this research is the following:

1. (RQ1) What are the objectives and type of research used in the article on the use of games-based learning media to support students' cognitive abilities in mathematics learning in 2013-2023?

2. (RQ2) What types of media and games are studied in the article on the use of games-based learning media to support students' cognitive abilities in mathematics learning in 2013-2023?
3. (RQ3) What is the impact of games-based learning media on students' cognitive abilities in the article on the use of games to support students' cognitive abilities in mathematics learning in 2013-2023?

Selection and Data Extraction

After determining the research questions, the next step is to search for articles and select the articles to be analyzed. Researchers make inclusion and exclusion as eligibility criteria for data found in research. Inclusion and exclusion criteria are shown in the following table.

Table 1. Inclusion and Exclusion Criterion

Criteria	Inclusion	Exclusion
Periode	2013-2023	Before 2013
Data type	National or international articles	Others
Language	Indonesia and English	Other than Indonesia and English
Research focus	Articles that are relevant to the use of game-based learning media to support students' cognitive abilities in mathematics learning	Articles that are not relevant to the use of game-based learning media to support students' cognitive abilities in mathematics learning

Articles were searched using Google Scholar, Springer Link, and Scopus databases using Publish or Perish. The search was carried out using the keywords "*media pembelajaran matematika berbasis* games", "games-based learning media", or "game-based learning media in mathematics". The search was limited to publication years 2013-2023. The data obtained from the search results were 1956 articles. Then, in the identification process, duplication of documents and the language used in the articles are checked. The selected articles are articles that use Indonesian or English. At the screening stage, researchers selected 1888 articles by reading the title, abstract, and keywords based on their suitability to the research focus of games-based learning media that supports students' cognitive abilities. Based on this selection, 86 articles were obtained.

In the assessing stage, researchers selected 86 articles by reading the entire article based on quality assessment (QA) criteria. So, based on these 3 stages, 17 articles were obtained. The process of determining the articles to be analyzed in this research can be seen in Figure 1. The assessment criteria refer to questions including:

1. (QA1) Does the article write about the objectives and types of research on the use of games-based learning media to support students' cognitive abilities in mathematics learning in 2013-2023?
2. (QA2) Does the article write about the types of media and games in the use of games-based media to support students' cognitive abilities in mathematics learning in 2013-2023?
3. (QA3) Does the article write about the impact of using games-based mathematics learning media to support students' cognitive abilities in mathematics learning in 2013-2023?

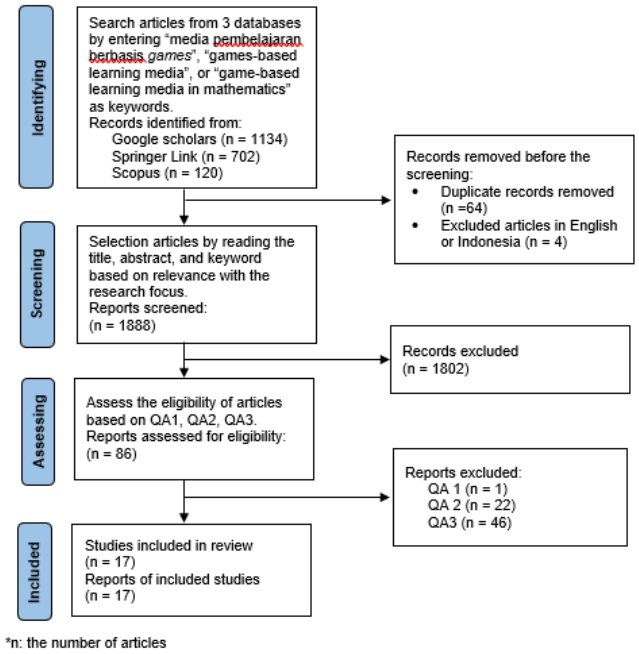

Figure 1. PRISMA Flowchart

Data Analysis

At the data analysis stage, researchers summarized information on 17 articles related to the author's name, year of publication, type of research, research objectives, types of media and games developed, and the impact of games on students' cognitive abilities. Then, from the presentation of the table, the researcher identified the differences, similarities, and disadvantages of each article used. The summary of the article information results table can be seen in Table 2.

RESULT AND DISCUSSION

The results of the literature review found 17 articles related to the use of games-based learning media to support students' cognitive abilities in mathematics learning. The results of the analysis of these articles can be seen in Table 2.

Table 2. The Result of Article Analysis Related to Research Topic

No	Authors and Publication Years	Research Types and Objectives	Media and Games Types	Impact
1	Amorim, A.N., Jeon, L., Abel, Y., Pape, S., Albuquerque, E.X.S., Soares, M., Silva, V.C., Aguiar, D., de Paula, C.A., Lopes, J., Silva, M.S., do Nascime, M.V., Patricio, G.A., da Silva, V.F., & Florentino, R. (2023)	Quantitative, to know the impact of mathematics game-based learning media	Digital games	Using Escribo Play in mathematics learning shows that students' understanding of the count-sequence, geometric shapes recognition, and spatial abilities is better than professional development programs.
2	Enjelita, Oktaviana, D., & Ardiawan, Y. (2023)	R&D, to produce game-based learning media	Digital games, quiz	Games can increase students' mathematical understanding abilities
3	Fajriani, G., Surani, D., & Fricticarani, A. (2023)	Quantitative, to know the impact of mathematics game-based learning media	Digital games	Educational games can improve the critical thinking skills of Generation Z students. In addition, learning using this game makes students enthusiastic and more active during learning activities.
4	Hasanah, N. (2023)	R&D, to produce game-based learning media	Conventional, puzzle	This media can be used to support critical thinking skills and reduce students' boredom levels.
5	Mumazizah, S., Fatih, M., & Alfi, C. (2023)	R&D, to produce game-based learning media	Conventional, boardgame	The game-based learning media can increase students' numeracy abilities.
6	Sulistiyo, D., Sutama., Setaningsih, R., Utami, N.S., Yansyah, M., Desmayanasaer, D., & Adnan, M. (2023)	R&D, to produce game-based learning media	Digital games, shooting games	This media is effective in improving mathematics learning outcomes. The media also can improve students' understanding of mathematical presentations in class.
7	Bang, H.J., Li, L., & Flynn, K. (2022)	Mixed method, to know the impact of mathematics game-based learning media	Digital games, story games	The use of games can increase students' motivation, self-confidence, and engagement in mathematics learning. Apart from that, learning using games can improve students' learning outcomes.
8	Chen, P.-Y., Hwang, G.-J., Yeh, S.-Y., Chen, Y.-T., Chen, T.-W., & Chien, C.-H. (2022)	Qualitative, to know the impact of mathematics game-based learning media	Digital games	Game-based learning increases students' motivation and engagement in mathematics learning. Game-based learning can also reduce students' anxiety. Besides, game-based learning also

No	Authors and Publication Years	Research Types and Objectives	Media and Games Types	Impact
				impacts higher-order thinking skills such as problem-solving, critical thinking, reasoning, and creative thinking.
9	Jensen, E.O., & Skott, C.K. (2022)	Qualitative, to know the impact of mathematics game-based learning media	Digital games	Using games in learning mathematics supports students' mathematical reasoning. Games allow students to explore, and make conjectures and justification. Apart from that, games can also build interaction between students and the dialogue of the games being played.
10	Qohar, A., Susiswo., Nasution, S.H., & Wahyuningsih, S. (2021)	R&D, to produce game-based learning media	Digital games, mix and match	Games can assist students in understanding similarity and congruence concepts. Additionally, games can also increase students' motivation, make students like mathematics, and give the experience to students as a winner.
11	Rofiqoh, I., Puspitasari, D., & Nursaidah, Z. (2020)	R&D, to produce game-based learning media	Digital games, adventure	Games can improve learning outcomes with presentations by 32,79%. In addition, learning activities with game-based learning media can also make students active because games increase students' enthusiasm for learning mathematics.
12	Salsabila, N.H. & Setyaningrum, W. (2020)	R&D, to produce game-based learning media	Digital games, adventure	STATIC Game can increase students' involvement so that students can build their understanding of mathematical concepts.
13	Setiawati, L. & Qohar, A. (2020)	R&D, to produce game-based learning media	Digital games, adventure	Gamemoti made learning activities more effective and fun for students, increased students' motivation, and trained problem-solving skills based on the difficulty level.
14	Kartika, Y., Wahyuni, R., Sinaga, B., & Rajagukguk, J. (2019)	R&D, to produce game-based learning media	Digital games, adventure	The result of this research is students; creative thinking improves when using game-based media during learning activities.
15	Pratama, L.D. & Setyaningrum, W. (2018)	Mixed method, to know the impact of	Digital games, adventure	The use of games in mathematics learning shows that this media is effectively

No	Authors and Publication Years	Research Types and Objectives	Media and Games Types	Impact
		mathematics game-based learning media		used in helping students understand the concepts of surface area and volume of geometric figures, as well as improving student learning outcomes.
16	Saputro, T.A., Kriswandani, & Ratu, N. (2018)	R&D, to produce game-based learning media	Digital games, adventure	Student learning outcomes improve after learning using the game-based learning media. Games are an interesting and not boring medium for students, and the subject presented in the media can help students understand algebra concepts and solutions.
17	Kyriakides, A.O., Meletiou-Mavrotheris, M., & Proromou, T. (2016)	Qualitative, to know the impact of mathematics game-based learning media	Digital games, puzzle	A.L.E.X is a puzzle game where the player controls a robot. These games allow students to experiment with geometric ideas in creating hypotheses and testing those hypotheses. The results of this research show that games can help students to improve student understanding. Apart from being beneficial for students' cognitive development, A.L.E.X games can also create an interactive environment, increase student motivation and engagement during mathematics learning, and create a new and conducive learning environment.

(RQ1). What are the objectives and type of research used in the article on the use of games-based learning media to support students' cognitive abilities in mathematics learning in 2013-2023?

There were 17 articles obtained regarding the use of games-based learning media to support students' cognitive abilities in mathematics learning in the 2013-2023 period. There were 2 research focuses found in the 17 articles. Figure 1 below shows the research objectives for 2013-2023 regarding the use of games-based learning media to support students' cognitive abilities in mathematics learning.

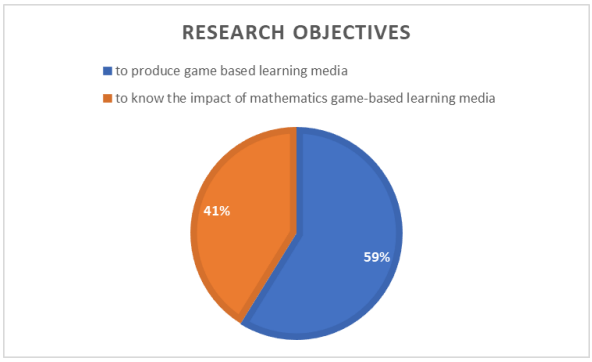

Figure 2. The Research Objectives

Based on Figure 2, there is 59% of the research aims to produce game-based learning media and 41% of the research aims to know the impact of the mathematics game-based learning media. The articles identify the effect of using game-based learning media on mathematics learning. Therefore, it can be concluded that research in the 2013-2023 period tends to focus on producing game-based learning media for mathematics learning. Meanwhile, there are 4 types of research used in these 17 articles. The types of research are Research and Development (R&D), quantitative, qualitative, and mixed methods.

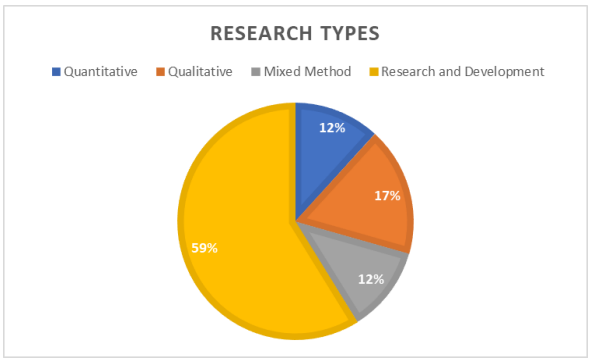

Figure 3. The Research Types

Based on Figure 3, it is known that 59% of studies use Research and Development (R&D). R&D is used to produce games-based learning media that is valid, practical, and effective for use in learning activities. Then, there are 17% of articles using qualitative research, 12% of articles using mixed methods, and 12% of articles using quantitative research.

(RQ2) What types of media and games are studied in the article on the use of games-based learning media to support students' cognitive abilities in mathematics learning in 2013-2023?

The types of media used consist of digital and conventional games. Figure 3 shows the types of media used in research on the use of mathematics games-based learning media.

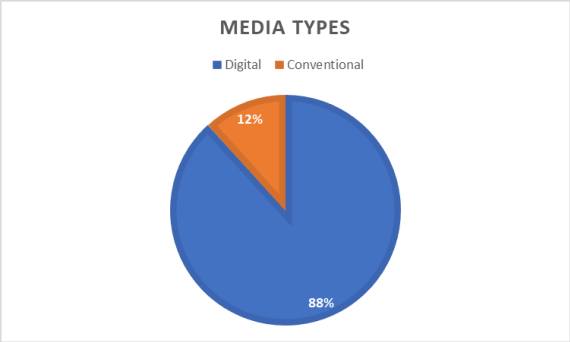

Figure 4. The Types of Media

In Figure 4 it is known that in 2013-2023 digital games tended to be used in research regarding the mathematics game-based learning media. Digital games are currently the most researched topic because the rapid development of technology can help teachers deliver material and carry out evaluations easily. Technology can facilitate learning activities and provide widespread access to knowledge (Fajriani et al., 2023). Research on digital games was also carried out because currently, most students like digital games. In line with Legowo et al. (2023) state that as many as 46 out of 80 students played Android-based games and 2 students played non-Android digital games.

Additionally, from the 17 articles described, 7 types of games were also obtained which were used in the research. A total of 4 articles discuss general types of games that support students' cognitive abilities in learning mathematics. A diagram of the types of games studied in research related to the use of games in mathematics learning is shown in Figure 5.

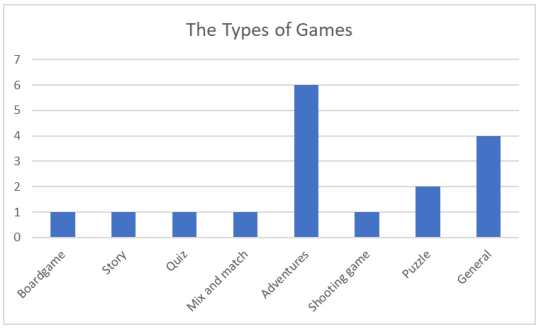

Figure 5. The Types of Games

In Figure 5 it is known that the games that tend to be studied in research regarding the use of game-based learning media to support students' cognitive abilities in mathematics learning for the 2013-2023 period are adventure games. In adventure games, students are instructed to look for objects before solving math problems. Adventure games can increase student enthusiasm so that students can easily understand mathematics

material. This is in accordance with Qohar et al. (2019) which states that students prefer adventure games because they have many challenges with various situations.

(RQ3) What is the impact of games-based learning media on students' cognitive abilities in the article on the use of games to support students' cognitive abilities in mathematics learning in 2013-2023?

Learning media plays an important role in learning activities. Choosing the right media can help students easily understand the subject given by the teacher so that learning can take place effectively and efficiently. One of the effective learning media used in mathematics learning is game-based learning media. According to Jensen & Skott (2022) game-based learning media designed for learning mathematics allows students to explore mathematical relationships and provides a framework so that students can determine conjectures and justify them, as well as compare and discuss different results with other students. In line with Khodijah et al. (2020), games that are modified to include elements of mathematics learning in it can help students better understand concepts.

Based on the results of a literature review analysis of 17 articles regarding the use of games-based learning media to support students' cognitive abilities in mathematics learning, it was found that games help students understand mathematics material easily (Pratama & Setyaningrum, 2018; Qohar et al., 2021; Saputro et al., 2018). This is because game-based media provides visual and audio effects so that abstract mathematical material can be transformed into more concrete. In addition, Amorim et al. (2023) state that an interactive learning environment and the application of evidence-based strategies with interesting content in the media are also factors that can improve students' understanding of mathematical concepts. The games featured in the media can also increase student enthusiasm and motivation so that students are more active in learning activities (Bang et al., 2022; Fajriani et al., 2023; Kyriakides et al., 2016; Qohar et al., 2021; Rofiqoh et al., 2020; Setiawati & Qohar, 2020). Thus, game-based learning media can also create an interactive, conducive, and new learning environment.

In terms of cognitive abilities, game-based learning media provides various positive impacts. Games-based learning media can reduce students' anxiety (Chen et al., 2022) and increase their self-confidence (Bang et al., 2022). Enhancement in self-confidence increases student learning outcomes. In line with the opinion of Enjelita et al. (2023), students' mathematical understanding abilities increased after carrying out learning activities with the help of game-based media. The presence of visuals and audio also shows

that games can improve students' mathematical communication and mathematical representation skills (Sulistiyo et al., 2023).

In addition, games support higher-level thinking abilities. Chen et al. (2022) state that games influence high-order thinking skills, such as problem-solving, critical thinking, reasoning, and creative thinking abilities. Fajriani et al. (2023) in their research revealed that game-based learning media can improve students' critical thinking abilities. In line with Hasanah (2023) critical thinking skills can be sharpened because students enjoy learning mathematics using game-based media. The problems given while playing the game cause students' competitive spirit to be motivated to solve them.

Games also support the development of problem-solving and mathematical reasoning skills. Games that are specifically designed to solve mathematical problems allow students to generate ideas, determine hypotheses, and test these hypotheses (Kyriakides et al., 2016). It is in line with Salsabila & Setyaningrum (2020) who stated that games designed with a problem-based learning model make students used to solving problems in real life so that it can help students understand mathematical concepts in their lives. Soldano et al. (2019) also revealed that games designed for mathematical reasoning help students find strategies to win, make mathematical statements, and validate or refute conjectures. The use of game-based learning media also shows an increase in students' creative thinking abilities (Kartika et al., 2019). Games designed with open problems give students the opportunities to make strategies for solving problems to win the game. Students can explore new and innovative ideas during the game (Himmawan & Juandi, 2023).

Based on the impact of games-based learning that has been described, it is known that games give students an idea of the relationship between mathematics and everyday life. The activities carried out by students during learning activities help students develop their thinking abilities (Purnomo et al., 2022). Students need to win games by understanding and formulating problems, using mathematical concepts and facts in solving problems, evaluating problem solutions, and communicating the problem solutions. Thus, games can also help students develop numeracy skills. This is in accordance with research by (Mumazizah et al., 2023) which states that learning activities that use game-based media also show an increase in students' numeracy abilities.

Based on the results of a literature review, it was found that digital games are a current trend because they involve technological advances to support 21st-century abilities. However, in these studies, there has not been an integration of digital games into culture. A

cultural context in mathematics learning activities is useful for developing student character while preserving culture. Therefore, in further research, it is necessary to develop digital games integrated with cultural contexts to support mathematical abilities.

It is hoped that the results of this study can become literature for researchers in identifying ideas for developing effective learning media through fun learning. However, this study only discusses game design which has the potential to develop students' cognitive abilities. It is expected for further research to discuss deeper how the learning process occurs so that games can support students' cognitive abilities.

CONCLUSION

Based on the results and discussion of a review of 17 research articles in the last decade, it can be concluded that the type of research that is widely used related to the use of games-based learning media to support students' cognitive abilities in mathematics learning is Research and Development (R&D). This research aims to produce games-based mathematics learning media that is valid, practical, and effective. Meanwhile, the type of game most studied is digital games with an adventure theme. Games-based mathematics learning media provide various positive impacts on students' cognitive abilities, such as numeracy abilities, problem-solving, critical thinking, reasoning, mathematical communication, and creative thinking. However, designing games for learning needs to pay attention to the indicators to be achieved so that games influence students' cognitive aspects. The research in the articles used in this literature review represents small-scale research. Researchers suggest that research related to the use of games to support students' cognitive abilities in mathematics learning can be carried out further in a wider scope.

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