



Games based learning in mathematics education: A systematic literature review

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Abstract: This study aims to describe and evaluate the effects of game-based mathematics learning. Systematic Literature Review (SLR) is used as a method in this research by collecting primary studies through checking the Google Scholar database, Education Resources Information Center (ERIC) from 2013 to 2022 with the keywords "games and learning mathematics" or "games and mathematics education", resulting in 25 relevant primary studies with inclusion criteria. The analysis technique used for the articles or primary studies that have been collected is that each primary study is recorded, then classified by title and year of study. Furthermore, each of the articles included in this study was analyzed to obtain the findings and discussion required to draw conclusions from this SLR study. It shows several results from the 25 articles used as material for the analysis of game-based mathematics learning, namely: 1) There are two types of games that are applied in the process of learning mathematics, namely traditional games, and modern games. 2) In general, the influence of the application of games, both traditional and modern, on learning mathematics is to improve the quality of learning with better indicators of teacher skills and student activity. From the results of this analysis, it can be concluded that the application of games in the process of learning mathematics is effective, because it affects the quality of learning mathematics in schools, especially by increasing student competence. The findings of this study also contribute to providing information related to the trend of game-based mathematics learning in Indonesia, which is expected to become recommendations and ideas for further research.

Keywords: Games based learning; Learning mathematics; Systematic Literature Review.

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INTRODUCTION

Education is an essential slice of the progress of a nation because an educated country can determine a better future direction. Education plays a critical role in equipping human resources to face the increasingly complex challenges and demands of life in the 21st century (Ramadhanti et al., 2022). Each individual must have various abilities because the knowledge obtained by a person is a form of effort to utilize the mind he has. One of the skills that need to be possessed is good mathematical thinking skills.

As part of society's culture, mathematics contributes to realizing society's overall goals. Mathematics is a universal knowledge that underlies modern development and has an essential role in developing human thinking power, as well as a means of communication about patterns of relationships that are useful for thinking logically, critically, creatively and systematically (Pujiyanto et al., 2020). Taking this into account, it is necessary to develop the thinking and



reasoning processes of the Indonesian people, especially the younger generation, through learning mathematics.

However, mathematics is one of the subjects that students avoid at school. As if it were a horror film, mathematics is scary for students at every school level. They need help understanding the material presented by the teacher. The teacher is too textual and relies on the material scheme in the LKS book or textbook, then students become good listeners, ask a few questions and answers, and students only take notes from the blackboard. A learning process like this is teacher-centered teaching (teacher oriented) and is not oriented toward student understanding (Muryani, 2018).

Student-centered learning is in line with the educational method applied by Ki Hadjar Dewantara, namely the "among" method. Among means guiding children with love and prioritizing the interests of children. Thus, the child can develop according to his nature. The relationship between students and tutors is like a family. How to teach and educate using the motto *Tut Wuri Handayani* implies encouraging students to get used to searching and learning on their own. Managing (a child) means guiding and giving children the freedom to move according to their will. The teacher or among follows behind and gives influence, is in charge of observing with all attention, and help is given when necessary (Natalia, 2015).

Skinner views that adults must exercise control over things that affect children's development so that children become a person (person) as desired by education. Even though in the learning process, children are given the freedom to develop and think creatively, there needs to be supervision from a teacher so that they can evaluate student performance. Therefore, learning tools need to be considered properly. When everything related to learning tools, be it models, learning methods, and others, are of high quality, then the learning outcomes obtained by students are, of course, of high quality, and vice versa.

The challenge of learning mathematics in the future is finding a form of learning mathematics in which all aspects can be studied as a whole (Sriyanto, 2017). Therefore, a teacher must be able to present exciting mathematics learning so that students do not feel challenged, bored, or even afraid of mathematics. One that is offered as a learning model is games' help. The game is an activity carried out by some children to seek pleasure which can shape the child's personality process and help children achieve physical, intellectual, social, moral and emotional development (Wahyudi & Siswanti, 2015).

The teacher must utilize the characteristics of students who like to play to create appropriate learning strategies for students. Teachers can use games to make learning fun for students. By including games in the learning process, it is hoped that students will be more motivated and interested in learning. However, the game must also be able to make students discover their own experiences. The teacher must continue to accompany them during learning so that in using games, students only play and joke with their friends with the purpose (Ulya, 2017).

Dienes' theory in Jannah (2013) argues that mathematical concepts will be easy and successful to learn through six stages, including (a) Free Play Stage, at this stage students learn mathematics through playing concrete objects without teacher direction, the important thing is that the objects used for playing are available; (b) The Game Stage, at this stage the children are also still playing with concrete objects but have been directed to observe patterns and regularities of a concept; (c) Searching for Communities Stage, at this stage children carry out learning activities to find similarities in traits through games designed by the teacher. (d) At symbolic Stage (Symbolism), students begin to create mathematical symbols or verbal formulas. For example, to write triangle ABC, it is symbolized by ΔABC ; (e) The stage of the game with representation, at this stage the students are looking for similarities like the situation, the students need an overview of the concept. Of course, the conceptual description is usually more abstract than the situation presented. This method directs students to understand the abstract mathematical structure contained in the concept; (f) Formalization Stage, in this last

stage, students learn to organize concepts to form a mathematical system that contains axioms, propositions, theorems and their consequences.

Based on this opinion, it can be understood that students and teachers feel the benefits of playing in the learning process. This is because the concept of playing activities is in great demand by school-age children who are at the stage of their psychological development, namely the age of adjustment. Activities that move a lot of limbs are very influential for the players' growth and development, especially when played by children. Especially if it is done with pleasure, it will result in a learning process for the players. Playing is a means of implementing newly acquired knowledge which is then practiced and consolidated according to the environment. That is, if in the process of playing activities a child finds a play rule or something new to him, then he will try to combine this new information with his cognitive structure.

METHOD

Research Question

The research questions in this study are 1) what types of games are being developed? and 2) what is the influence of the game in the learning process?

Research Design

This study uses the systematic literature review (SLR) method. Systematic literature review identifies, assesses, and explains all research related to a particular research question, topic area, or phenomenon of interest (Kitchenham, 2004). The protocol used in this study refers to The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement which includes four stages as follows: (1) identification, (2) screening, (3) eligibility, (4) included (Liberati et al., 2009). This was done to achieve a high-quality systematic literature review as a determinant of suitability and quality with the objectives of this SLR study.

Inclusion Criteria

Inclusion criteria in this study were used as eligibility standards in selecting primary studies. All primary study articles obtained from the initial search were examined and assessed using inclusion criteria to obtain research data following the research objectives so that the Systematic Literature Review in this study is more focused and specific. The PICOS (Population, Intervention, Comparator, Outcomes, Study design) approach can be applied to determine more specific inclusion criteria (Liberati et al., 2009).

Thus, the inclusion criteria in this SLR study were determined based on the PICOS approach as follows: (1) primary studies that focus on learning at various levels of education in Indonesia (population), (2) primary studies that discuss the application of game-based learning (intervention), (3) the intervention comparison group in the primary study was the application of conventional learning models or other models as a control class (comparison). experimental research with causal-comparative type (study design). 6) The journals used as data analysis are in the last 10 years, namely 2013 - 2022. 7) SINTA and SCOPUS index the types of journals used. 8) The languages used as data are Indonesian and English.

Literature Search Strategy

Collection of primary studies by checking the Google Scholar database, Education Resources Information Center (ERIC) with the keywords "games and learning mathematics" or "games and mathematics education". Using these databases and keywords aims to obtain relevant primary studies that match the inclusion criteria.

Study Selection Process and Data Analysis

At the identification stage, 62,200 journals were obtained based on a search of study literature via Google Scholar. At the screening stage using the first inclusion, that is, a span of

10 years, only 18,100 journals remained. After screening, the researchers were eliminated other than the study articles used for data analysis and the remaining 142 journals. After that, the researchers also only used accessible journals and not proceeding articles, so that there were 130 journals left. Furthermore, in the Education Resources Information Center (ERIC) there were 47,843 journals found, after going through the filtering stage with year-range inclusion, only 13,817 journals remained. The next stage is to download dozens of journals related to the topic of this SLR study and to consider further inclusion, namely the language used, in this case, Indonesian and English. Then, through the last inclusion process, which Sinta and Scopus indexed, only 20 journals from Google Scholar and 5 journals from ERIC remained. Thus, 25 journals are used as data analysis in this SLR study.

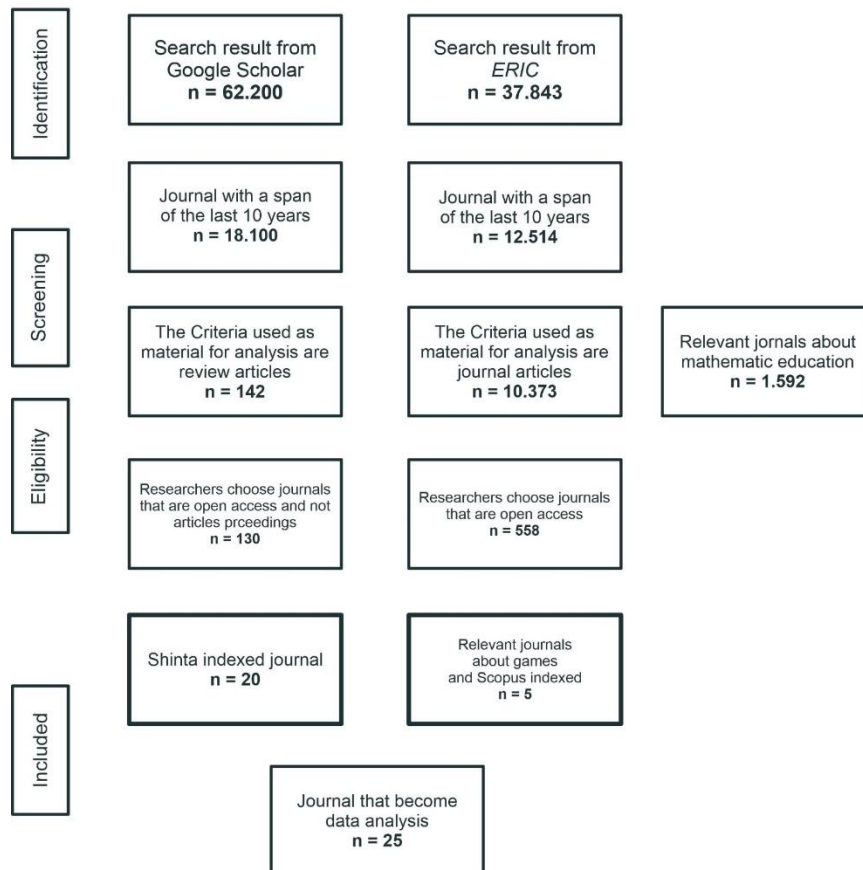


Figure 1. Study selection process and data analysis

The analysis technique used for the articles or primary studies collected is that each primary study is recorded, then classified by title and year of study. Furthermore, an analysis was carried out one by one of the articles included in this study to obtain findings and discuss the conclusions in this SLR study.

RESULTS AND DISCUSSION

Game-Based Learning Models

Many experts are looking for alternative learning presentations that aim to make students active in the learning process, especially at school. According to Arsyad in (Ulfah et al., 2016), learning media can be used to convey messages or information in the teaching and learning process to stimulate students' attention and interest in learning. In order to achieve maximum learning outcomes, choosing learning media needs to pay attention to the psychological conditions of students who vary at each level.

The characteristics of elementary school students between the ages of 6 and 13 are in the concrete operational phase. Piaget stated that in this phase the abilities and processes of thinking in operating logical rules are still concrete. The five senses still bind all objects that are captured. The learning process in the concrete phase goes through various stages: concrete, semi-concrete, semi-abstract and abstract. In studying abstract mathematics, students need media aids to make learning material easier to understand (Ferryka, 2018).

Game-based learning media is considered a solution to the monotonous mathematics learning process. Apart from the difficult material, the general learning process in schools is only teacher centered. Finally, students are not active and have minimal involvement in the learning process. This learning media is relevant to the psychological conditions of school-age children who need tools to understand abstract lesson concepts such as mathematics. Many studies have shown positive results from applying game-based mathematics learning media, both traditional and modern.

Table 1. Characteristics of traditional game-based learning

Game Type	Effect	Authors
<i>Permainan Sirkuit</i>	Motivation	(Nugraheni, 2017)
<i>Monopoli</i>	Motivation	(Rahaju & Hartono, 2017)
<i>Ular Tangga</i>	Motivation, improving students' calculating and analyzing skills	(Nugraheni, 2017) ; (Seruni et al., 2019)
<i>Dengklaq</i>	Student Motivation and Character	(Fauzi & Lu'luilmaknun, 2019)
<i>Permainan Ku Ku Ku Kalung Bilangan Papan Saku</i>	Students' Calculating Ability	(Dwirahayu & Nursida, 2016)
<i>Permainan Ludo</i>	Student Collaboration Skills	(Ulhusna & Diana, 2020)
<i>Tebak-Tebak Buah Manggis</i>	Student Understanding	(Hariastuti R, 2017)
<i>Kartu UMINO</i>	Improving Learning Outcomes	(Srintin et al., 2019)
<i>KARTIKA (Kartu Matematika)</i>	Improving Learning Outcomes	(Wulandari et al., 2020)
<i>Congkak/Congklak</i>	Improving Student Character, Mathematical Communication Ability, Student Understanding	(Zafirah et al., 2018); (Ulya, 2017); (Siregar et al., 2014); (Sari et al., 2019)
<i>Kartu UMATH (Uno Mathematics)</i>	Improving Learning Outcomes	(Rahmatin & Khabibah, 2016)
<i>Kelereng</i>	Training Children's Fine Motor Skills	(Pratiwi & Pujiastuti, 2020)
<i>Teka-Teki Silang</i>	Improving Learning Outcomes	(Muhtarom et al., 2016)
<i>Kartu Kwartet</i>	Improving Learning Outcomes	(Khabibah & Prasetya, 2016)
<i>Papercraft</i>	Improving Creative Thinking Ability	(Budiwaluyo & Muhid, 2021)

Based on the table above, the types of traditional games and their influence on the development of students at school in participating in the mathematics learning process are presented. Next, we will identify and discuss the characteristics of traditional game-based learning, especially those applied to learning mathematics in schools.

Increase Learning Motivation

Traditional games applied to learning mathematics at school can influence student learning motivation. This is evidenced by several studies that have been conducted. First, according to (Nugraheni, 2017) which applies Circuit Games, Monopoly and Snakes and Ladders in learning

mathematics at the Elementary School level. Second, research (Fauzi & Lu'luilmaknun, 2019) presents Dengklaq-assisted mathematics learning. The results of the study show that game media can arouse students' enthusiasm, foster feelings of pleasure during the learning process. This feeling encourages students to continue to practice developing their abilities.

Improving Students' Counting and Analyzing Skills

The application of traditional games in learning mathematics affects students' calculating and analyzing skills. At least two studies claim this influences the process of learning mathematics. First, according to (Seruni et al., 2019) who innovated in learning mathematics by implementing a game of snakes and ladders. Second, research (Dwirahayu & Nursida, 2016) which developed the "Ku Ku Ku Game" method in learning mathematics for grade 1 students of Madrasah Ibtidaiyah. The results showed that learning with the game method could improve students' numeracy skills. In addition, students' ability to analyze a mathematical problem also increased.

Forming Student Character

Game-based learning can also affect the formation of student character. As in several previous studies that discussed this effect. First, according to (Fauzi & Lu'luilmaknun, 2019) which presents Dengklaq assisted mathematics learning. This game trains students' concentration and also increases their intelligence because they are trained to count step by step that must be passed in the game. In addition, this game also trains students to socialize with their friends. Second, research from (Zafirah et al., 2018) which makes the Congkak Game a learning medium. This research shows that there are nine characters in Congkak Game which are used as a medium for learning mathematics. The nine-character values are honesty, discipline, hard work, creativity, curiosity, independence, communicative responsibility and respect for achievement.

Student Collaboration Skills

One study showed that game-based mathematics learning can train students' collaboration skills. According to Ulhusna and Diana (2020) who implemented the Ludo Game in learning mathematics. The study results show that learning mathematics combined with ludo games can improve students' collaboration skills. This game allows students to be more dominant in the learning process. The involvement of these students can create a sense of mutual need and work together to think of strategies to achieve team victory. At the same time, this game can stimulate students' good mathematical thinking.

Improving Student Understanding

Traditional game-based mathematics learning methods can also increase student understanding. One of them is research from Hariastuti (2017) which uses mangosteen fruit as a medium for learning mathematics in elementary school students. It turns out that Guessing the Mangosteen Fruit, which is used as a learning medium can increase students' understanding of mathematical material. Students can understand the concept of addition by counting the number of mangosteen peel petals. In addition, another study from (Siregar et al., 2014) uses Congklak as a medium for learning mathematics. The results showed that this game became an intermediary for students in understanding the concepts of addition, subtraction, multiplication, and division.

Improving Learning Outcomes

The application of traditional games in learning mathematics can improve student learning outcomes. This is evidenced by several studies examining games' effect on learning outcomes. First, research from Srintin et al. (2019) regarding the development of UMINO Card Game media in mathematics learning. Second, research from Wulandari et al. (2020) regarding the effectiveness of Card Games as a medium for learning mathematics. Third, research from

Rahmatin and Khabibah (2016) which developed the UNO Mathematics Game as a learning medium. Fourth, research from Muhtarom et al. (2016) concerning the application of crossword puzzles in learning mathematics for junior high school students. Finally, research from Khabibah and Prasetya (2016) presents mathematics learning assisted by the Quartet Card Game. The study results show that applying traditional games in learning mathematics can improve student learning outcomes. Fun math learning can help make it easier for students to learn math. In addition, the application of this game with an attractive appearance makes students enthusiastic in learning and the material is easier for students to understand.

Mathematical Communication Skills

Learning mathematics presented using the game method can train students' mathematical communication skills. Evidenced by research conducted by Zafirah et al. (2018) regarding the Congklak Game assisted learning method. The results showed that there was an increase in students' mathematical communication abilities after being given treatment in the form of the application of the Congklak game. This ability is needed as a step in pursuing optimal learning outcomes.

Training children's fine motor skills

Mathematics learning that combines presentation concepts with traditional games can train children's fine motor skills. Such as research conducted by Pratiwi and Pujiastuti (2020) regarding marble-assisted mathematics learning. The results showed that the movement of flicking marbles can train children's fine motor skills. This skill can control children's emotions so they can focus on what is being faced.

Improving Creative Thinking Ability

The final effect of the application of games in learning mathematics is that it can improve creative thinking skills. Relevant research was conducted by Budiwaluyo and Muhid (2021) regarding Papercraft Games in the early childhood learning process. The study results show that this game will stimulate children to think creatively. So that they can bring up new ideas and new models of work made by them. The application of this fun game keeps children involved in generating new and innovative ideas, especially in learning mathematics.

Table 2. Characteristics of modern game-based learning

Game Type	Effect	Authors
Serious Game	Improve student skills	(Barbieri et al., 2021)
Computer Games	Improving Computational Thinking Ability, Increasing Motivation, Facilitating Student Understanding	(Soboleva et al., 2021); (Liu et al., 2022); (Russo et al., 2020)

Based on the table above, types of modern games are presented and their influence on the development of students at school in participating in the mathematics learning process. Next, we will identify and discuss the characteristics of modern game-based learning, especially those applied to learning mathematics in schools. (1) Improving Student Skills and Computational Thinking Ability, the application of modern games in learning mathematics affects students' skills and computational thinking abilities. Research conducted by Barbieri et al. (2021) claims that there is an influence of the game "Serious Game" in the process of learning mathematics. (2) Increasing Motivation and Increasing Student Understanding. The application of modern games in learning mathematics affects students' motivation and understanding. Research conducted by Soboleva et al. (2021) claims that the game "Computer Game" influences the process of learning mathematics.

Based on the table above, in general the types of traditional and modern games influence the development of students at school in participating in the mathematics learning process.

Next, we will identify and discuss the characteristics of traditional and modern game-based learning, especially those applied as a method of learning mathematics in schools.

Table 3. Characteristics of game-based learning

Game Type	Effect		Source
	Student Activity	Teacher Skills	
Traditional	✓	✓	(Setiawan, 2020) ; (Nugraha & Suryadi, 2016)
Modern	✓	✓	(Zabala-Vargas et al., 2022)

Traditional and modern games have a positive impact on student activities as well as teacher skills in teaching. Several studies support this argument, namely research from Nugraha and Suryadi (2016) on traditional game methods in teaching mathematics in elementary school children. Furthermore, there is research from Setiawan (2020) discussing traditional game-based mathematics learning in elementary school children. In addition, research on modern games also shows the same thing, namely research from Zabala-Vargas et al. (2022) on "Didactic Strategy Mediated by Games in the Teaching of Mathematics in First-Year Engineering Students" or mediated mathematics teaching with games.

CONCLUSION

The application of game-based mathematics learning has several influences divided into two, namely traditional and modern games. Overall, traditional games found in several articles influence increasing student motivation, students' calculating and analyzing skills, student understanding, creative thinking skills and learning outcomes as well as shaping student character, student collaboration skills, mathematical communication skills as well as training children's fine motor skills. Meanwhile, modern games' influence is increasing students' motivation and understanding and training students' skills and computational thinking abilities.

The 25 articles used as material for analysis of game-based mathematics learning show several results, namely: 1) There are two types of games that are applied in the process of learning mathematics, namely traditional games, and modern games. 2) In general, the influence of the application of games, both traditional and modern, on learning mathematics is to improve the quality of learning with better indicators of teacher skills and student activity. From the results of this analysis, it can be concluded that the application of games in the process of learning mathematics is effective, because it affects the quality of learning mathematics in schools, especially increasing student competence.

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