The Effect of Educational Game in Mathematics Learning: A Review

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**Abstract**. This research aims to review of educational games used in learning mathematics. With current technological developments, there needs to be innovation in learning mathematics considering that many students still having difficulties to learn mathematics. By using educational games, it is expected to motivate students to be more enthusiastic in learning mathematics, because the interesting and fun educational game features will attract the attention of students. Therefore, a review will be conducted on the effect of using of educational games in mathematics learning of several previous research studies in terms of several aspects, namely the function and impact of the game on mathematics learning, as well as learning topics based on the level of education. Based on its function, the educational game as a complement that stimulates student learning so that it can improve the way of thinking, interacting with each other, fostering students' confidence in learning mathematics. Based on the learning topic, educational games are used for elementary school level on multiplication, division, geometry. In secondary school, educational games are suitable for use in the topics of learning geometry and algebra. The findings obtained from 30 analysed studies show that the use of educational games is effectively used in teaching and can improve mathematics learning skills. However, several studies have shown that the use of games as learning is not significant for learning mathematics. Other results indicate there are game tools that cannot be used in the long period so further development is needed in further research. The results of this study will be used as recommendations in the further development of educational games for learning mathematics.

1. **Introduction**

Mathematics is a very important subject and is studied at all levels of education, from elementary, junior high, high school, and university. However, some students consider mathematics to be difficult subject so they do not like mathematics. In line with Sedig's opinion in Costu [1], many students do not like learning mathematics and often perceive mathematics as an unpleasant subject. High school students find mathematics is boring and difficult to be engaged in creative or social aspects [2]. Lack of motivation and student involvement causes ineffective learning. Based on this fact, efforts are needed so that students are more interested in learning mathematics and easier to understand mathematics, one of which is by creating a kind of educational game. In addition, interesting and fun educational game features can attract students' attention and curiosity, when compared to reading textbooks.

Educational games are games in which there is learning that can provide students with learning experiences. As the opinion of Holzinger, et al. [3] stated that computer games can provide students with opportunities to develop cognitive knowledge and skills emotionally, students become more independent by making decisions in solving problems when situations are critical, and being able to observe learning situations. Games can develop imagination and creativity that have a meaningful context in learning [4]. Educational games can encourage students to learn because the content and animation in very fun games can make students interested in playing them. By connecting games in the world of education, it can have a positive impact on increasing student interest in learning, to increase student enthusiasm for learning. Games also make it easier for students to receive material taught by the teacher. According to Simkova [5], educational games in mathematics learning are educational games that provide positive influence and results with the desired goals in the mathematics learning process.

Mathematics is a subject that is widely used in various fields such as economics, technology, and society. However, there are problems in the mathematics learning process at the elementary to the higher level education, where most students perceive mathematics as a subject that is difficult to understand and learn. On the other hand, technology has developed very rapidly and affects the education. Many innovations have been made in an effort to overcome those problems, one of which is the development of educational games. It is considered that the development of educational games for mathematics learning will always be carried out in accordance with technological developments.

Various learning resources and learning media are scattered on the Internet and easily accessible without limits of distance and time, including those related to learning mathematics. There are many publications on research that aim to create educational games for mathematics learning, along with the development of digital technology. In this regard, it is necessary to conduct a study to find out how far the role of educational games is in learning mathematics from several previous studies. In addition, it is also important to know the impact of mathematics educational games on the development of students' thinking, communication and self-confidence. Considering the need for the development of educational games for mathematics learning, for further development recommendations, it is necessary to review research in previous related fields. Therefore, this study aims to review the research in educational games used in learning mathematics.

1. Mathematics Educational Game

## Educational Game

According to [6], the game is a device with various rules in which players use strategy to achieve certain results and goals. Games are played to entertain and give pleasure. The game serves as a means to practice and can be used in educational activities, as well as a simulation. Educational games are games that are connected to the world of education as a learning medium with interesting, interactive, and fun features that invite players involved in the game to play while learning [7]. Educational games are also a combination of educational content, learning activities, and computer games that can attract players' attention to learn. Games affect the improvement of cognitive abilities, communication skills, interaction skills, and student self-confidence.

## Game for Mathematics Learning

Mathematics learning is a process of understanding abstract mathematical concepts. According to Heckenberg, et al. in Bai et al. [8] games can help in the process of learning mathematics with abstract and visual concepts. In the learning process, when the teacher teaches, students find it difficult to understand mathematical concepts even though the teacher has given examples. By using digital technology, students can easily understand abstract mathematical concepts designed by computers. Gee and Ke Into Bai et al. [8] also stated that games provide students with active learning in simulations, problems, and feedback quickly.

1. Method

The research aims to analyze the effectiveness of educational games in learning mathematics from the results of previous studies. Therefore, the data used are the results of previous research publications in terms of math educational games. The research publication used as data sources were taken from various scientific journals, among others are Google Scholar, Science Direct, Springer, Kluwer Academic Publisher, Research Gate, Wiley Online Library, International Electronic Journal of Elementary Education, British Journal of Educational Technology, International Journal of Online Biomedical and Engineering, Semantic Scholar, Journal of Mathematics Education at Teachers College, and Textbooks.

Research studies relevant to educational games in mathematics learning are searched using some keywords, such as educational games, educational games in education, and educational games in learning mathematics. Analysis of the effectiveness of the game includes the following stages:

1. Collecting the data, namely obtaining information or data from research publications that relation to educational games in learning mathematics
2. Analyzing the data, namely classifying, describing, examining the results of the study whether the effect was produced or other results were displayed. The analysis was carried out based on several aspects, namely the function and impact of games on mathematics learning, types of games, and learning topics based on educational levels.
3. Writing conclusions, namely drawing an outline of the effectiveness of educational games from the research publication.
4. Result and Discussion

## Research Data

Based on the collected research publications, it can be said that the educational game is used at all levels of education, from Kindergarten to Higher Education. These studies show that educational games are variedly utilized as an integrated part of mathematics learning, teaching methods, and teaching complements. The existence of a positive impact was also described in all these studies, namely the enjoyment of learning, enhancement of learning, and also the existence of effectiveness. The following is the research publication data, which is grouped by level of education.

***Table 1*** *Summary of educational games in mathematics learning*

|  |  |  |
| --- | --- | --- |
| Level of education | Utilize | Result |
| an integrated part of math learning | teaching methods | teaching complements | enjoyment of learning | enhancement of learning | useful in learning | effectiveness |
| Kindergarten | [10] |  | [9] | [9] |  |  | [10] |
|  |  |  |  |  |  |  |  |
| Elementary School | [11][12][13][14][16][17][18][19][20][22][23][24][25][26][27][29] | [15][28] | [16][18][21] | [11][12][13][14][18][21][24] | [15][20][22][23][25][26] | [16][17][26][29] | [19][21][27][28] |
|  |  |  |  |  |  |  |  |
| Junior High School | [18][22][23][25][30] | [18] | [2][21] | [2][18][21] | [22][23][25] | [30] | [21] |
|  |  |  |  |  |  |  |  |
| Senior High School | [31][32][30][33] | [34] |  | [33] | [30] | [31] | [32][34] |
|  |  |  |  |  |  |  |  |
| All Level School | [35] |  | [36] | [36] | [35] |  |  |

## Results of Data Analysis

Based on table 1, analysis of the effectiveness of educational games will be reviewed from several aspects, including its function, type, topics studied, and educational level.

1. *The function of educational games*

Referring to table 1, it can be said that educational games are used in various ways as an integrated part of mathematics learning, teaching methods, and teaching complements. Based on these results, it can be seen that educational games show effects that can be grouped into three, as described below.

1. *Games Have A Positive Effect So That Students Enjoy Learning Mathematics*

Educational games are used as learning media that help students learn so that they are interested and easily understand mathematics. This is stated in [21] that students enjoy games as a means of learning mathematics. The use of educational games also makes learning more fun [18]. This is also in line with Ku's [37] research that students feel more comfortable doing game-based mathematics learning because it is more fun. According to Winjers, et al. [40], the game media is very interesting and interactive so that students are motivated, enjoy playing, and students can learn. The research of Nkopodi & Mosimege [31] also shows that students enjoy the games used in a mathematics class in providing mathematics learning and the use of games can provide direct interaction between students when communicating the activities carried out. In line with Chen, et al. [26] that math games can be useful in learning mathematics because they are considered interesting, fun, and help students in the learning process. Students are interested and like to learn using educational computer games [34].

1. *Games Can Enhance Math Learning*

Games have the potential to improve student learning and motivation in learning mathematics [23]. The use of educational games can develop students' attitudes and motivation towards mathematics [18]. Mathematical games can provide students with more experience, their problem-solving abilities and problem-posing skills can increase higher [19]. Besides, the e-book based game learning model is effective in increasing students' motivation to learn mathematics [24]. Prahmana, et al. [20] made a multiplication learning math game using game tools to help students understand multiplication and the results showed that the game increased student motivation and stimulated students to understand the concept of multiplication. Mathematics games are used as a medium of learning to improve students' mathematical skills [32]. The use of games in the mathematics teaching process can positively affect students' academic achievement [36]. Byun & Joung [38] analyzed digital game-based learning for mathematics education for grade XII SMA using meta-analysis and the results of the analysis showed that many were interested in using digital game-based learning so that it increased significantly, but some digital games needed quality improvement. Using game-based technology in the classroom benefits students of all ability levels in all mathematics learning skills [16].

1. *Effective Games for Teaching and Learning Mathematics*

Educational computer games can be used to support teaching methods [12]. The teacher suggests that this math game can be an alternative in learning mathematics in the future [32]. In addition, the game also serves as teacher assessment media, as well as stated in [27] that games are effectively used for mathematics assessment and can provide detailed mathematical knowledge. Games are effectively used in learning, it can influence students in learning mathematics, therefore students suggest using games as an effective means of learning mathematics [21]. Video games are also an effective learning strategy for learning mathematics in class XII [34]. This shows that digital games are effective in learning mathematics compared to conventional learning [19][21][27][28][29][30][32][38]. Educational games have also proven to be a careful choice [29] and most students like to play the game repeatedly [13]. However, some studies argue that computer games can be used in teacher training for teaching and can increase student attention, but not significant for mathematics learning [35].

1. *Type of Educational Game*

Even though they have the same term, i.e. educational games, the types of games in these various studies vary widely. There are several types, both digital and non-digital or traditional, such as an animated instruction game, E-book based games, Traditional Clapping Game, etc. An animated instruction game "Millionaire" can improve students' problem-solving and problem-posing skills in learning mathematics [19]. An E-book based games provide a positive influence on students' mastery and understanding of concepts in number operations [10]. A mini-games for multiplication also employed as mathematics learning media, but there are weaknesses in playing this mini-game, namely, students have difficulty playing interpreting numbers and do not support long-term use [6] An online archery games have an effect on improving students' math skills and become an alternative for teachers in teaching [32]. The Original Moraraba Game has a positive influence on learning mathematics with students liking games, students can also interact and communicate with their peers, and the original Moraraba game can be used in a multicultural environment [31]. Traditional Clapping Game (PT2B) can stimulate the understanding of students' knowledge in learning the concept of multiplication [20], and digital game-based learning such as video games has a positive impact on student motivation [33].

1. *Mathematical Topics Studied*

From several studies analyzed, the topics in mathematics learning that are taught are material on multiplication, division using previous knowledge, and being able to find new rules in division, algebra, geometry (squares, rectangles, and parallelograms), and probability. Some of these materials show that they can be used and suitable to be combined into games as a medium for learning mathematics.

1. *Level of Education*

Mathematics is learning that is taught in almost all levels of education. From kindergarten, elementary school, middle school to college. In the research that has been analyzed, the use of educational games in learning mathematics is used at the levels of elementary school, junior high school, and high school. Brezovszky, et al. [28] examined using the math game method for elementary schools. However, from that study, because the level of analysis of the knowledge of the students in grades 4, 5, and 6 was different, the research was made separately for each different grade level. Furthermore, Jonker, et al [13] also examined mini-games designed to explore distribution material in grades 4 and 6 of elementary school. Apart from that, games are also useful for vocational school educated students [30].

Lowrie & Jorgensen [15] also examined the use of math games based on gender and in their research showed that there were significant gender differences in playing math games. Male students prefer to play math games that involve visual or spatial. Meanwhile, female students prefer to play math games that require problem solving. Ke [22] stated that game-based learning is dynamic in terms of time, content, style, and feedback from students. Students succeeded in solving problems with online games compared to using paper and pencils for which there was no direct feedback. The feedback generated by the game stimulates student-generated feedback [14]. So that educational games are effectively used in elementary, junior high and high school classes.

## Discussion

In the previous session, the analysis of the effects of educational games on mathematics learning from several research publications has been explained. The use of games in mathematics learning has a positive effect on students. Through the concept of fun games, students are motivated and challenged to solve math problems. Apart from students, teachers also find it helpful when teaching using game-based learning tools because it can increase student attention and student understanding in receiving learning. Moreover, there are several studies that design game-based mathematics learning tools, including video games, mini-games designed to explore division materials, e-book-based games, and math learning games for multiplication material using the Traditional Picture Tap Game (PT2B).

Some of these learnings show that game tools can help teachers in the learning process making it easier for students to learn. One of the reasons that make educational games have a positive effect is because the learning mode in games is carried out through a series of activities that actively involve students. Figure 1 shows an example of a game application that displays interactive activities that attract students' attention using animation [19]. The game has a continuous series of activities, namely game levels, feedback, and rewards in the form of prizes for winning. Students are challenged to complete the questions given at each level in such a way that it gives students the opportunity to reopen the subject matter in an attempt to win the game. It can be said that the activities designed have made students directly involved in playing the game so as to provide a pleasant experience for students in the mathematics learning process.



***Figure 1*** *Example of digital game application [19]*

The aim of providing mathematics learning using educational games is to gain knowledge through students' personal experiences by suggesting schools and teachers involve students in meaningful learning experiences. The role of the teacher is needed to provide teaching that can develop students' mathematical thinking processes rather than assimilating mathematical formulas. When teacher uses games, it can help to improve students' creativity and attitudes towards mathematics [39]. Most students feel bored with the conventional teaching and learning process. Thus, learning mathematics based on educational games can provide student experience in learning so that it can increase student interest and academic achievement. In addition, educational games lead to other influences that are also positive for students, namely cognitive abilities, communication skills, and student motivation in learning mathematics.

From the previous description, it can be argued that in today's growing era and increasingly advanced technology, the use of educational games has influenced the lives of students, and teachers must be able to start using technology that can help in the learning process. In the world of education, learning is always connected to real life which is so inherent in students' daily lives. This approach should be applied to help students face difficulties in understanding mathematical concepts and determine strategies for solving mathematical problems. Incorporating technology into education is the best way so such an extent that students can learn and practice continuously, teachers are also able to teach complex mathematical concepts easily [40].

1. Conclusion

Based on description above, it can be concluded that educational games are very influential in mathematics learning. The use of educational games in mathematics learning can attract students' attention so that students do not feel bored when learning mathematics. Educational games can also increase students' creativity in thinking to solve problems in mathematics. There are evidences from several studies that teaching and learning mathematics activities based on educational games can provide students with meaningful learning experiences, increase student interest in learning, and improve mathematics learning achievement. This shows that there are positive changes in students who initially dislike and feel bored in learning mathematics to be challenged so that students enjoy learn mathematics. In spite of the fact that there are many research studies in educational games for learning mathematics, the need to improve the quality of educational game development in learning mathematics is always demanded. This is known from several educational game that cannot be used in the long term, so there is a need for further developments.

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