

THE EFFECTIVENESS OF EDUCATIONAL GAMES IN LEARNING MATHEMATICS AMONG SECONDARY SCHOOL STUDENTS

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ABSTRACT

Educational games in learning have established an alternative learning environment among students. It helps to improve students' knowledge and skill acquisition. Through educational game learning, it provides students with challenges and a sense of accomplishment. The challenges in teaching-learning mathematics subjects are student's lack of problem-solving skills and lack of interest during the lessons. Therefore, this study aims to implement educational games in learning mathematics to increase students' interest and determine its effectiveness. The study was conducted in one of the secondary school districts of Seri Manjung, Perak. A cluster sampling technique was used which comprised 32 respondents from the Form One level. Quantitative data were collected from questionnaires and academic achievement tests. The Social Sciences Statistical System (SPSS) version 25 tool was used to analyse the data. The findings showed significant differences in the students' achievement in learning mathematics by using educational games as their learning aids. Based on the results, it can be concluded that student's performance in mathematics improved after they participated in the educational game activity as a learning aid in the classroom. Therefore, it is advised that future studies focus on several topics and increase the number of participants in educational games as learning aids in mathematics.

Keywords: Academic Achievement, Educational Games, Mathematics.

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1. Introduction

Educational games are purposeful activities that feature certain actions and rules that are carried out by the teacher to further the emotional and cognitive educational aims. In addition, it helps the students to learn and improve several skills as they play, such as sharpening students reasoning, creativity, and memory. The world becomes more innovative as technology advances, and learning through games can help to boost student motivation. The result of adopting this teaching technique has shown that including games in teaching-



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learning activities is quite successful (Kraht *et al.*, 2021). Educational games can be divided into two types of games which are digital games and non-digital games. Digital refers to the technological games that can only be played on electronic devices such as a computer, smartphone, or other such device. Meanwhile, non-digital games refer to any board, card, or other type of game that may be played in a physical setting. The study conducted by Jääskä *et al.* (2022) showed a positive result on game-based learning. It helps to sustain students' interest and motivation in learning. Furthermore, a meta-analysis study conducted by Tokac *et al.* (2019) found that game-based learning is an effective instructional strategy for learning mathematics for students. Overall, educational game setting has proven to improve student academic achievement and mathematics motivation.

An article cited by Wong & Wong (2019) mentioned that the result of PISA 2009 showed that Malaysian students' assessment in mathematics literacy was below minimum benchmarks. Then, the result of PISA 2012 for mathematics literacy received a mean score of 421 which is below the OECD average and Malaysia was placed 52nd out of 65th countries that took part in it. There was a trend of fluctuation in the mathematical performance of students in Malaysia. According to Aguilar (2021), students have a negative perception of learning mathematics due to a lack of understanding and self-perception of low content knowledge. Thus, it is significant to conduct a study on the effectiveness of educational games as learning aids in mathematics for secondary school students. This study aims to evaluate the effectiveness of educational games as learning aids. Thus, this study specifies the following research questions.

- a) What are the students' achievements in mathematics?
- b) Is there any significant difference in using educational games as learning aids?
- c) What is the student's perception of educational games as learning aids?

In the next section, this study discusses related works on educational games in mathematics. Then, it is followed by the method of the study and the last section presents the result and conclusion.

2. Related Works

Mathematics involves investigating measurements, numerical concepts, geometric shapes, algebraic principles, and various other mathematical components. Mathematics plays an essential role in every aspect of life in everyday matters such as knowing the time, calculating wages or discounts, and performing jobs like engineering, banking, finance, medicine, and others. It is also needed to learn other knowledge like science, social science, and many more. In other words, mathematics is crucial in many fields and disciplines. Insufficient proficiency in mathematics restricts students' access to a wide array of essential subjects, thereby constraining their future career prospects and depriving society of a potential resource of individuals proficient in quantitative skills (Li & Schoenfeld, 2019). As mathematics has significant value in life, teaching and learning methods should use various tools including game-based learning or educational games.

According to Zeng *et al.* (2020), at present, the academic community is unable to define the mutual meaning of educational games whether serious games and light games fall under the same terms or not. Zeng *et al.* (2020) stated that educational games involve the use of computer applications that enable learning and entertainment at the same time as students use educational games. Plass *et al.* (2020) defined game-based learning as learning through the use of games or competition at different levels to make learners more excited about learning the knowledge. Usually in a game, there are many levels with clear rules on how to play the games (Plass *et al.*, 2020). Meanwhile, Becker (2021) stated that game-based learning involves learning tasks and skills through the use of game software. This could include learning knowledge through playing games and learning through building games (Becker, 2021).

Learning through educational games has been widely discussed in several papers, with various effects and benefits observed for the learners. Van Putten (2020) conducted a

study by using collaborative game-based worksheets of mathematics for grade 6 students in South Africa. The focus is more on mathematical knowledge rather than focusing on selected topics in mathematics. The result showed that educational collaborative game-based worksheets have a positive influence on the students as the worksheets improved their confidence, skill, understanding, and achievement. A study conducted by Malliakas *et al.* (2021) used board games as an intervention strategy in helping dyslexic students aged 12-13 years old from Greece to improve their mathematics performance. The special-needs students require comprehensive analytical programs for the existing practice. Designing exercises and practices is a challenging process that requires many different skills to develop mathematical abilities. The findings from the study showed a positive effect of integrating board games into mathematics on dyslexic students (Malliakas *et al.*, 2021). As cited in a meta-analysis study conducted by Hui and Mahmud (2023), the issue raised is that implementing educational games in learning may not be as effective. This could happen because the competence level of the student can impact how well educational games work for them. In addition, teachers face difficulties in creating personal educational tools to accommodate the varying levels of mathematical proficiency among students (Hui & Mahmud, 2023). A systematic review of research articles conducted by Vankúš (2020) found that 84 % of studies on the integration of educational games into learning produced a positive influence. Furthermore, Mansor & Rosly (2024) discovered that digital game-based learning helps in student-centered learning process and significantly improves students' achievements in mathematics. Meanwhile, the rest of the studies appeared to be mixed, possibly due to various factors such as flaws in the research instruments used, the selection of study groups, and the design of the games themselves. These factors can significantly influence the effectiveness and outcomes of gamification implementations in educational settings.

Numerous empirical studies have extensively examined the use of educational games as a learning tool in mathematics education. However, it remains unclear whether these educational games also contribute to enhancing students' achievement and interest in learning mathematics intrinsically in this study. Moreover, there is a limited number of studies that specifically target selected topics in which students are weak. Hence, further investigation is necessary to determine the effectiveness of educational games as a tool for improving mathematical interest and achievement on selected topics of mathematics among secondary school students.

3. Methodology

This study was granted ethical approval from the Ethical Committee, Universiti Teknologi MARA. The investigation was conducted at one of the secondary schools in Peninsular Malaysia. Written consent from participants was attained from the school principal and the parents were assured of the confidentiality of participant information.

The participants in this study comprised 32 students from Form One secondary school in the district of Seri Manjung, Perak. A quasi-experimental (pre-test and post-test) design was conducted for this study. The sample was selected via cluster sampling due to the limited number of students participating in this study. There was no other group of students; thus, the participants were considered both the control and intervention groups. As for the intervention strategy, the students were given mathematical exercises on the topics of Rational Numbers and Factors & Multiples. They had to answer the exercises via online interactive educational games tools which are Quizziz, Wordwall, and Kahoot. The exercises were designed based on the standard topic syllabus endorsed by Kementerian Pelajaran Malaysia (KPM). These games can be accessed on any type of device such as a laptop, desktop, or smartphone. The questions were designed using a variety of game genres or themes such as game show quizzes, random wheels, dark night, football, and matching. At the end of the game, the scoreboard is displayed.

Pre-test and post-test of mathematics performance were conducted in this study on 2 topics which are Rational Numbers and Factors & Multiples of Curriculum and Assessment

Standards Document (KSSM) Form One mathematics syllabus. The questions consisted of 2 parts which are multiple choice questions and short structure questions. The participant has to answer the questions within 60 minutes. The content validity of the pre-test and post-test was verified by three different mathematics teachers in which one of the senior teachers has an experience of more than 15 years in the specialization of mathematics subject. The feedback from these experts was used to strengthen the validity of the pre-test and post-test questions. Furthermore, this study distributed a questionnaire to investigate the student's perception of the effectiveness of educational games as a teaching tool in mathematics. It requires the respondents to select their responses using the Likert scale. The options available to the respondent are 1 (Strongly Disagree), 2 (Disagree), 3 (Neutral), 4 (Agree), and 5 (Strongly Agree). The reliability of the questionnaire was assessed where the Cronbach's alpha was 0.779 which is more than 0.75.

The quantitative data were analysed using the Social Sciences Statistical System (SPSS) version 25. The statistical method used to investigate the students' achievement in learning mathematics was descriptive analysis. Next, descriptive analysis and paired sample T-tests were used to evaluate the effectiveness of the educational game as a learning aid on students' achievement in mathematics.

4. Result And Findings

4.1 Research Question One

What are the students' achievements in mathematics?

Table 1. Descriptive Statistics for Students' Achievement Before Using Educational Games as Learning Aids

	N	Min	Max	Mean	Std. Deviation
Achievement Score Before Using Educational Game	32	22	92	52.75	16.623

Table 2. Descriptive Statistics for Students' Achievement After Using Educational Games as Learning Aids

	N	Min	Max	Mean	Std. Deviation
Achievement Score After Using Educational Game	32	30	88	59.44	13.737

Table 1 shows the descriptive statistics achievement score before using educational games. The result was average, where students had moderate achievement in the pre-test on mathematics subjects (Mean=52.75, SD=16.623). The lowest score was 22 and the highest score was 92, and there was a score range of 70 marks between the lowest and the highest score. Table 2 shows the descriptive statistics achievement score after using educational games. The lowest score was 30 and the highest score was 88, with a range of 58 marks between the before and after using educational games. Thus, the result shows some improvement in the achievement score before and after using educational games as a learning aid. The educational games help the weak student who scores 22 marks before using educational games to perform better after using the educational games. In addition, educational games reduced the score range of marks before and after using the educational games.

Table 3. Summary of Students' Achievement of Educational Games as Learning Aids

	N	Mean	Std. Deviation	Std. Error Mean
Achievement Score Before Using Educational Game	32	52.75	16.623	2.939
Achievement Score After Using Educational Game	32	59.44	13.737	2.428

Table 3 shows the summary of descriptive analysis of students' achievement in mathematics. The students were given a set of questions related to two topics before and after the students used the educational game as their learning aid. The pre-test was given to find their level of achievement in mathematics subjects without using the educational game as a learning aid. The post-test was given to determine their level of achievement in mathematics after using the educational game as their learning aid. Before using the educational game, the students had a mid-low achievement in mathematics (Mean= 52.75, SD=16.623, SE=2.939). After using the educational game as a learning aid, the student's achievement in mathematics slightly increased (Mean=59.44, SD=13.737, SE=2.428). This indicates that the intervention strategy used in this study, which involves online educational games as learning aids, has a positive effect on student's understanding of the two topics tested.

4.2 Research Question Two

Is there any significant difference in using educational games as learning aids?

H₀: There is no significant difference in the effect of educational games as learning aids on students' achievement in mathematics.

H₁: There is a significant difference in the effect of educational games as learning aids on students' achievement in mathematics.

Table 4. Paired Sample Test Students' Achievement Before and After Using Educational Games as Learning Aids

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95 % Confidence Interval of the Difference				
				Lower	Upper			
Achievement Score Before using Educational Game - Achievement Score After using Educational Game	- 6.687	9.593	1.696	-10.146	-3.229	-39.43	31	.000

In Table 4 it displays the paired sample test results which determine the significance difference before and after using educational games. The analysis indicates a significant difference (t = -39.43, df = 31, p < 0.05). Consequently, the null hypothesis was rejected, suggesting that there is indeed a difference in mathematics achievement before and after using educational games as learning aids. Overall, these findings demonstrate a positive effect on students' achievement in mathematics after using educational games as learning aids in class. Therefore, we accept the alternative hypothesis, which proposes a significant difference in the effect of educational games as learning aids on students' achievement in mathematics.

4.3 Research Question Three

What is the student's perception of educational games as learning aids?

Table 5(a) Descriptive Statistics of Students' Perception of Educational Games as Learning Aids

No	Description	N	Mean	Std. Deviation	Variance
Q1	I can understand the lesson taught through the educational game as learning aids in mathematics subject.	32	4.41	0.665	0.443

Table 5(b) Descriptive Statistics of Students' Perception of Educational Games as Learning Aids

No	Description	N	Mean	Std. Deviation	Variance
Q2	The use of educational games as learning aids improves the performance of mathematics subjects.	32	4.31	0.644	0.415
Q3	I can increase my memory when learning the mathematics subject through educational games as learning aids.	32	4.31	0.592	0.351
Q4	The use of educational games as learning aids is not able to improve my understanding of the concept of mathematics.	32	4.06	1.134	1.286
Q5	I love to learn using educational games as learning aids in mathematics subject.	32	4.47	0.621	0.386
Q6	I feel fun when the teacher teaches mathematics subject using educational games as learning aids in class.	32	4.59	0.615	0.378

Table 5(a) and Table 5(b) show the positive result on the student's perception of the educational games as a learning aid in learning Mathematics. The highest mean score refers to item Q6, "I feel fun when the teacher teaches mathematics subject using educational games as learning aids in class" (Mean=4.59, SD=0.615). It is followed by item Q5, "I love to learn using educational games as learning aids in mathematics subject" (Mean=4.47, SD=0.621). The student can understand the lesson when using educational games with a mean score of 4.41. The items Q2, "The use of educational games as learning aids improves the performance of mathematics subject" and Q3, "I can increase my memory when learning the mathematics subject through the educational games as learning aids" had the same mean score (Mean=4.31), respectively. The lowest mean score was from item Q4, "The use of educational games as the learning aids is not able to improve my understanding to learn the concept of mathematics" (Mean=4.06, SD=1.1344). Therefore, these findings indicate that the intervention strategy has increased students' perception of learning mathematics on the specified topics.

5. Conclusion

The results of this study reveal that the use of educational games in mathematics among secondary school students has a positive effect. The finding of this study corresponds with the studies conducted by Yu *et al.* (2020) and Yeşilbağ *et al.* (2020) which analysed the effect of educational games in mathematics and found that educational games effectively improve students' academic performance and increase the students' interest.

This study also shows the achievement scores of the students in mathematics when using and not using educational games. The achievement of the weakest student increases when the teacher uses educational games as a learning aid during the lesson. Furthermore, the findings show that there is a positive effect of educational games as a learning aid. In addition, this study reveals that the students have a strong positive perception of educational games in learning mathematics. Most of the respondents feel fun in learning as they like the topics more and their understanding of the topics increases when the teacher uses educational games as learning aids during the lesson. It can be concluded that the use of educational games as learning aids in mathematics is beneficial to the students.

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Author Contribution

Nur Hanani wrote the methodology, conducted the statistical analysis, and interpreted the results. Nurhilyana prepared the literature review, oversaw the article writing, and interpreted the results. Aminatul Solehah prepared the literature review and oversaw the article writing.

Conflict of Interest

The authors have no conflicts of interest to declare.

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