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Enhancing Fifth Graders' Flat Geometry Problem-Solving Skills through STEM-Based 'Squid Math' Gamified Learning Media

Yuni Mariyati[1], Intan Dwi Hastuti[2], Reny Widya Astuti[3]
[1,2,3]Department of Primary Education, Universitas Muhammadiyah Mataram, Pagesangan, Indonesia
[1]rennywdyasti433@gmail.com, [2]intandwihastuti88@ummat.ac.id, [3]yunimariyati31@gmail.com.

ABSTRACT

This study investigates the effect of implementing the STEM-based "Squid Math" game on fifth-grade students' problem-solving abilities in plane geometry. The study employed a quasi-experimental method with a nonequivalent control group design. The participants consisted of 15 fifth-grade students from SDN 2 Jerowaru as the experimental group and 23 fifth-grade students from SDN 2 Paremas as the control group. The research instrument used was an essay test that had been tested for validity and reliability. The data were analyzed through normality testing, homogeneity testing, and hypothesis testing using the Independent Samples T-Test with the assistance of SPSS 25. The findings revealed that the experimental group's mean score increased from 53.67 in the pre-test to 84.17 in the post-test, whereas the control group's mean score improved from 41.26 to 61.85. The implementation of learning activities reached 100% in the experimental group and 95% in the control group. The hypothesis test produced a significance value of $p = 0.000 < 0.05$, indicating a significant difference between the two groups. Therefore, the STEM-based "Squid Math" game media significantly contributed to improving fifth-grade students' problem-solving skills in plane geometry. This learning media is recommended as an innovative alternative for mathematics instruction in elementary schools.

Keywords: STEM, Squid Math, Problem-Solving Skills, Flat Shapes.

Corresponding Author:
Reny Widya Astuti,
Department of Primary Education,
Universitas Muhammadiyah Mataram,
Jalan KH Ahmad Dahlan No 1 Mataram, Indonesia.
rennywdyasti433@gmail.com

1. INTRODUCTION

Education constitutes an essential process in developing human potential in a holistic manner, including cognitive, affective, and psychomotor dimensions. Santoso and Widodo (2022) state that education is a structured and deliberate endeavor carried out by both individuals and institutions to establish a supportive learning environment, allowing students to acquire the knowledge, skills, and attitudes required for participation in social and professional contexts. This perspective is consistent with Rahmawati et al. (2022), who argue that education extends beyond the transmission of knowledge and serves as a process of value and character formation that prepares learners to respond effectively to global challenges in the digital era.

In the 21st-century context, education serves as a means of fostering a wide range of competencies, particularly critical thinking, creativity, collaboration, and communication (4Cs), which are vital for producing human resources that are both adaptive and innovative (Putra & Wulandari, 2021). In addition, Nurhasanah et al. (2022) explain that contemporary education should incorporate digital technology into the teaching and learning process in order to promote learning experiences that are interactive, individualized, and contextual, in accordance with current societal demands. Similarly, Wibowo and Lestari (2023) maintain that education functions as a process that supports the comprehensive development of students by implementing an inclusive and learner-centered approach. However, evidence from recent studies indicates that the use of digital technology in mathematics learning remains limited and has not been fully optimized to support students' higher-order thinking and problem-solving skills. Engelbrecht and Borba (2024) reported that digital technologies in mathematics classrooms are still predominantly utilized for content delivery and routine instructional activities, rather than for facilitating meaningful exploration,

inquiry, and mathematical problem-solving. This condition suggests a discrepancy between the expectations of 21st-century education, which emphasize interactive and student-centered learning through technology integration, and the reality of classroom practices. Consequently, there is a need for innovative digital learning media that not only incorporate technology but also actively engage students in solving mathematical problems through meaningful and contextual learning experiences.

From a theoretical standpoint, the learning process outlined above is strongly associated with constructivist theory, which views students as active participants who build their own understanding through interaction and experience. Likewise, experiential learning theory emphasizes that knowledge develops through direct involvement, reflection, and the application of concepts in meaningful situations. These ideas are further supported by the principles of game-based learning, where components such as challenges, immediate feedback, interaction, and rewards are able to increase learners' motivation and cognitive involvement. Taken together, these theoretical perspectives suggest that interactive, contextual, and student-centered learning environments can make a substantial contribution to the development of higher-order thinking skills, particularly problem-solving abilities.

Mathematics plays an essential role in developing students' ability to think logically, critically, and systematically. Therefore, mathematics learning needs to be organized in a contextual and meaningful way, enabling students to comprehend mathematical concepts more effectively and use them to solve problems found in everyday life (Hastuti, 2022). In elementary education, mathematics holds a particularly important position in strengthening students' cognitive development, especially in the field of geometry. One of the basic topics within this field is two-dimensional shapes, which are widely applied in various daily contexts.

Nevertheless, many students still encounter difficulties in comprehending these abstract concepts. A number of studies indicate that conventional teaching methods, which are generally passive in nature, are less effective in enhancing students' interest and understanding of the material (Rokhim, 2021). Mathematics instruction that is overly rigid and theoretical, without being connected to meaningful contexts, often results in only a superficial grasp of concepts. Therefore, instructional innovation is needed to help students develop a deeper understanding through learning experiences that are more active and enjoyable. One effective strategy is to relate mathematical concepts to real-life situations and students' own experiences, thereby making learning more meaningful and engaging (Hastuti et al., 2025).

The use of learning media grounded in Science, Technology, Engineering, and Mathematics (STEM) represents one strategy for addressing these challenges, as it connects mathematical concepts with technological elements and practical applications in real-life contexts. STEM-based learning emphasizes active student involvement and has been proven to improve learners' critical thinking and problem-solving skills (Anggraini et al., 2021). Furthermore, STEM-oriented educational games have been reported to enhance students' learning motivation and deepen their understanding of mathematical concepts (Nurussofa & Astuti, 2023). Educational games also help create a pleasant learning environment, motivating students to engage more actively while making it easier for them to understand the material being studied (Kero & Wewe, 2024).

Conceptually, the integration of STEM and game-based learning can be viewed as a process in which interdisciplinary STEM elements are incorporated into interactive instructional activities. This combination produces a gamified learning environment that promotes greater student engagement, motivation, and active participation. These conditions support a deeper understanding of concepts, which in turn leads to improved problem-solving abilities. Accordingly, the relationship among these components can be described as a sequential process: STEM integration → gamified learning experience → enhanced engagement and conceptual understanding → improved problem-solving skills.

Based on the researcher's observations conducted on April 3, 2025, students' problem-solving abilities, particularly in the topic of two-dimensional shapes, were still relatively low. Most students experienced difficulties in identifying and distinguishing various types of plane figures and were not yet able to relate mathematical concepts to their practical use in everyday situations. One of the primary factors contributing to this condition was the limited availability of interactive and contextual learning media. As

a result, students tended to memorize formulas without fully understanding their underlying meaning and fundamental principles. Therefore, it is necessary to provide learning media that actively engage students in meaningful learning experiences.

Problem-solving ability is a cognitive competence that involves a sequence of strategic processes, including understanding the problem, devising a plan, carrying out the chosen strategy, and evaluating the results, as proposed by Polya (Hartati & Adawiyah, 2023; Lestari et al., 2021). These stages demonstrate that effective instruction should offer students opportunities to participate actively in solving problems rather than merely receiving information passively.

A commonly applied solution in previous studies is the use of educational games to enhance students' understanding of mathematical concepts. Learning media such as *Squid Math*, which integrates game elements with STEM-based instruction, has been shown to increase student engagement and strengthen conceptual understanding in mathematics (Handican et al., 2023; Yuliani et al., 2023). Moreover, STEM-oriented games provide opportunities for students to solve authentic problems and develop critical thinking skills (Kedhi et al., 2024). The incorporation of game media inspired by popular culture can also create learning experiences that are more attractive and relevant to students' interests (Yustina & Yahfizham, 2023). In addition, video- and game-based instructional media have been found to improve both student motivation and learning outcomes (Prasetyo & Nugraheni, 2024).

Although previous research has confirmed the effectiveness of game-based learning and STEM approaches, most studies have examined these components independently or have not integrated them into a single, coherent instructional design. In addition, many studies have concentrated on overall mathematics achievement rather than specifically investigating problem-solving skills in geometry, particularly in the topic of two-dimensional shapes. Furthermore, research that combines STEM-based learning, gamification, and culturally relevant game adaptations such as *Squid Game* remains relatively limited.

Therefore, the novelty of this study lies in the simultaneous integration of three key elements: STEM-based learning, gamified instructional media, and the adaptation of culturally relevant game features through *Squid Math*. In contrast to previous studies that generally emphasize only one or two of these aspects, this research offers a more comprehensive approach by embedding STEM principles within a structured, contextual, and engaging game-based learning environment. In addition, the study specifically focuses on improving students' problem-solving abilities in plane geometry, an area that has received comparatively little attention in prior research.

Squid Math is a game-based mathematics learning concept that adapts elements from popular games to enhance students' engagement and mathematical abilities through challenges that incorporate cognitive, strategic, and social-emotional dimensions (Li, 2024; Yoon, 2023; Chonnia & Izzah, 2022). This game fosters an interactive, competitive, and collaborative learning environment that encourages students to think critically and solve problems effectively. In addition, it supports the development of character traits such as teamwork and emotional regulation (Park, 2024; Kim & Park, 2022). Nevertheless, its implementation must be carefully guided to ensure that educational objectives remain the primary focus and are not overshadowed by entertainment elements.

Several gaps identified in the existing literature include the limited number of studies that comprehensively investigate the influence of STEM-based game media on elementary students' understanding of two-dimensional shapes (Nurussofa & Astuti, 2023; Oliviana et al., 2024). Furthermore, research integrating culturally relevant game adaptations into STEM-based mathematics instruction is still relatively scarce. This indicates the need for further studies on innovative learning media that combine these components.

Accordingly, this study aims to examine the effect of STEM-based *Squid Math* game media on the problem-solving abilities of fifth-grade students in the topic of plane geometry. It is expected that this research will contribute both theoretically and practically by offering an innovative instructional approach that integrates STEM and game-based learning to improve students' understanding, engagement, and problem-solving skills in mathematics.

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2. RESEARCH METHOD

a. Research Design

This research employed a quantitative approach using a quasi-experimental method with a nonequivalent control group design. This design was selected because random assignment of participants into different groups could not be conducted; therefore, the study made use of the existing classroom groups. The research involved two groups, namely an experimental group that received instruction through STEM-based Squid Math gamified learning media and a control group that was taught through conventional instruction assisted by flashcard media. In this study, the STEM-based Squid Math learning media served as the independent variable, while students' problem-solving ability in plane geometry functioned as the dependent variable. The purpose of the study was to examine the effect of the STEM-based Squid Math game on students' problem-solving skills compared with conventional teaching methods.

b. Population and Sample

The population in this study included all fifth-grade students of SD Negeri 2 Jerowaru and SD Negeri 2 Paremas in the 2025/2026 academic year, totaling 38 students. Since the number of students was relatively limited, the entire population was used as the research sample. A purposive sampling technique was applied in this study by considering several factors, such as the implementation of the same curriculum, similar school characteristics, and comparable students' academic backgrounds. One class was assigned as the experimental group, while the other class served as the control group.

c. Research Procedure

The research was conducted through three main stages:

1. Pre-test Stage
   At this stage, both the experimental and control groups were administered a pre-test to identify students' initial problem-solving abilities in the topic of flat geometry.
2. Treatment Stage
   During the treatment stage, the experimental group participated in learning activities using STEM-based "Squid Math" gamified media, which combines mathematical concepts with interactive game elements. In contrast, the control group received instruction through conventional teaching approaches supported by flashcard media.
3. Post-test Stage
   Following the treatment, both groups were given a post-test to determine the improvement in students' problem-solving abilities.
   Through these stages, the researcher was able to compare the outcomes of the two groups and evaluate the effectiveness of the treatment.

d. Data Collection Technique

The data were obtained through a problem-solving ability test presented in the form of fill-in-the-blank questions with a structured essay format. The test was developed based on several indicators of problem-solving ability, namely:

1. identifying and understanding the problem,
2. formulating a solution strategy,
3. carrying out the selected solution, and
4. reviewing and evaluating the results.

To maintain measurement consistency, the same instrument was administered in both the pre-test and post-test.

e. Instrument Test

1) Validity Test

   Validity testing was conducted by comparing the predetermined criteria with the actual conditions or situations observed. The validity of the instrument was examined after it had been administered to users or respondents by applying the Pearson Product Moment correlation. In testing external validity, SPSS version 25 for Windows was utilized, using the following formula:

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$$r_{XY} = \frac{N\sum XY - (\sum X)(\sum Y)}{\sqrt{(N\sum X^2 - (\sum X)^2)(N\sum Y^2 - (\sum Y)^2)}}$$

Table 1. Interpretation of Validity Coefficients

Coefficient Interval	Category
0,00 – 0,199	Very Low
0,20 – 0,399	Low
0,40 – 0,599	Moderate
0,60 – 0,799	High
0,80 – 1,000	Very High

2) Reliability Test

Reliability testing was performed to determine the consistency of the instrument in measuring students' abilities. An instrument can be considered reliable when it produces stable and consistent results when administered repeatedly. In this study, the instrument reliability was analyzed using the Cronbach's Alpha method, which is suitable for essay-type tests. The reliability coefficient was calculated with the support of SPSS version 25. The criteria for interpreting the reliability coefficient are shown in Table 2**.**

Table 2. Criteria for the reliability coefficient of the instrument

Harga r	Description
0.00 – 0,20	Very Low
0,21 – 0,40	Low
0,41 – 0,60	Moderate
0,61 – 0,80	High
0,81 – 1,00	Very High

f. Data Analysis Technique

The data analysis process was carried out in several steps. The first step involved conducting prerequisite tests, which consisted of:

1. normality testing, to identify whether the data followed a normal distribution, and
2. homogeneity testing, to examine whether the variances between the groups were equal.

After these prerequisite assumptions were fulfilled, hypothesis testing was conducted using the Independent Sample T-Test to determine whether a significant difference existed between the experimental and control groups. All statistical analyses were completed with the assistance of SPSS version 25.

3. RESULTS AND DISCUSSION

The data in this study were analyzed using several statistical procedures, including normality testing, homogeneity testing, and hypothesis testing through the Independent Samples T-Test.

a. Prerequisite Test Analysis

1) Normality Test

The normality test was conducted to examine whether the data for each variable were normally distributed. In this study, the Shapiro-Wilk test was applied. The decision-making criterion was based on the significance value (Sig.); if the Sig. value was greater than 0.05, the data were considered to be normally distributed. The results of the Shapiro-Wilk test are presented in Table 3 below:

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Table 3. Normality Test Results

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Kelas	Statistic	df	Sig.	Statistic	df	Sig.
Hasil Kemampuan Pemecahan Masalah	Pretest_Kontrol	,160	23	,130	,936	23	,146
	Postest_Kontrol	,124	23	,200*	,929	23	,106
	Pretest_Eksperimen	,190	15	,150	,928	15	,256
	Posttes_Eksperimen	,133	15	,200*	,948	15	,496

Referring to the results shown in the table, the Shapiro-Wilk test was employed to assess the normality of data in both the experimental and control groups by considering the significance (Sig.) values. At a 5% significance level, the data were classified as normally distributed when the obtained significance value was greater than 0.05. Conversely, when the significance value was equal to or below 0.05, the data were interpreted as not normally distributed.

2) Homogeneity Test

The homogeneity test was performed to examine whether the data variances between the two research groups were equal. The data were categorized as homogeneous when the significance value was greater than 0.05, while a significance value lower than 0.05 indicated that the variances were not homogeneous. In this study, the homogeneity of variance was tested using Levene's Test (F test), with the analysis conducted through SPSS version 25 for Windows.

Table 4 Homogeneity Test Results
Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Hasil Kemamapuan Pemecahan Masalah	Based on Mean	1,123	3	72	,346
	Based on Median	,997	3	72	,399
	Based on Median and with adjusted df	,997	3	59,434	,400
	Based on trimmed mean	1,120	3	72	,347

Table 4 indicates that the significance value for the experimental and control groups is 0.346. Since this value is greater than 0.05, it can be concluded that the variances of the two groups are homogeneous.

b. Hypothesis Testing

The prerequisite analysis results indicated that the problem-solving ability data obtained from both the experimental and control groups were normally distributed and showed homogeneous variances. Since these assumptions had been fulfilled, hypothesis testing was then carried out using SPSS version 25 for Windows. The hypothesis was tested using the Independent Samples T-Test as the statistical analysis technique.

Table 5. Hypothesis Test Results

Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means					95% Confidence Interval of the Difference	
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper

Hasil	Equal variances assumed	,483	,491	-7,066	36	,000	-22,31884	3,15871	-28,72500 -15,91268
	Equal variances not assumed			-7,014	29,335	,000	-22,31884	3,18184	-28,82321 -15,81447

The hypothesis testing results showed a p-value of 0.000, which was below the 0.05 significance level, with a degree of freedom (df) of 36. This result indicates that the null hypothesis was rejected, while the alternative hypothesis was accepted.

Based on the descriptive statistical results, the use of STEM-based Squid Math game media was found to have a significant influence on enhancing students' problem-solving abilities. This can be seen from the increase in the experimental group's mean score, which improved from 53.67 in the pre-test to 84.17 in the post-test. This considerable increase indicates that the combination of STEM-based learning and educational game media offers a more meaningful learning experience and facilitates students' thinking processes in solving mathematical problems. In addition, the implementation of learning activities in the experimental group reached 100%, suggesting that the game media was implemented highly effectively and supported the learning process in accordance with the stages of the STEM approach.

The improvement may also reflect stronger cognitive engagement among students. Through interactive game-based learning activities, students were actively engaged in examining problems, trying out different strategies, and reflecting on the accuracy of their responses. This learning process aligns with the development of 21st-century 4C competencies, particularly critical thinking and creativity, since students were required to analyze mathematical problems, formulate possible solutions, and adjust their strategies within the game-based learning context.

In the control group, which received instruction through the Project Based Learning (PjBL) approach, students also showed progress in problem-solving abilities; however, the improvement was lower than that of the experimental group. The implementation of learning activities in the control class reached 95%. The average score of the control group increased from 42.17 in the pre-test to 60.00 in the post-test. Although the PjBL approach contributed positively to students' problem-solving skills, STEM-based learning assisted by Squid Math media resulted in a greater improvement. These results suggest that the intervention implemented in the experimental group was more effective than the instructional approach applied in the control group.

The results of the normality and homogeneity tests indicated that the data from both groups were normally distributed and had homogeneous variances. These findings confirm that the assumptions required for hypothesis testing using the Independent Samples T-Test had been met. The hypothesis test yielded a significance value of $p = 0.000$, which was less than 0.05. Thus, it can be concluded that a statistically significant difference existed between the problem-solving abilities of students taught using STEM-based Squid Math game media and those taught through the Project Based Learning (PjBL) approach.

In addition to the quantitative findings, qualitative data obtained through semi-structured interviews were analyzed to further explore students' mathematical problem-solving processes after participating in the STEM-based "Squid Math" learning activities. Representative interview responses are presented in Table 6.

Table 6. Representative Interview Findings

Problem-Solving Indicator	Interview Question	Representative Student Response
Understanding the problem	What information did you identify before solving the geometry problem?	"I first identified the known measurements and what the question asked before choosing the formula."

Planning the solution	How did you decide which strategy or formula to use?	"I selected the formula based on the shape shown in the game because each challenge reminded me of the correct concept."
Carrying out the solution	Can you explain how you solved the problem?	"I solved it step by step, starting from writing the formula, substituting the numbers, and calculating the answer."
Reviewing the solution	Did you check your answer after finishing? Why?	"Yes, I recalculated it because I wanted to make sure my answer was correct."
STEM learning experience	How did the STEM activities help you solve the geometry problems?	"The activities helped me understand how geometry is used in everyday situations, making the problems easier to solve."
Gamified learning experience	Which feature of Squid Math helped you the most?	"The levels, challenges, and instant feedback motivated me to keep trying until I solved the problems correctly."

The representative interview responses presented in Table 6 support the quantitative findings of this study. Overall, students in the experimental group demonstrated a better understanding of the mathematical problem-solving process after participating in the STEM-based "Squid Math" learning activities. Most students were able to identify relevant information from geometry problems, determine appropriate solution strategies, explain the solution procedures systematically, and verify the correctness of their answers. In addition, students reported that the STEM activities helped them relate geometric concepts to real-life situations, while the gamified features, such as challenges, levels, and immediate feedback, encouraged them to remain engaged and motivated throughout the learning process. These findings suggest that the integration of STEM principles with gamified learning not only improved students' mathematical problem-solving performance but also promoted reflective thinking and active participation during mathematics learning.

These findings suggest that the learning process supported students' reflective thinking, particularly in monitoring and evaluating their own problem-solving strategies. The interview responses indicated that many students consciously identified relevant information, selected appropriate solution strategies, and rechecked their answers before reaching a final solution. These learning behaviours reflect a more systematic approach to mathematical problem solving and reinforce the potential of STEM-based gamified learning to promote deeper engagement during mathematics instruction.

The findings of this study are consistent with those reported by Rosita Putri (2023), who found that STEM-based learning significantly improved students' mathematical problem-solving abilities. The increase in students' post-test scores observed in the present study further supports the argument that integrating STEM principles into mathematics instruction provides meaningful learning experiences that promote analytical thinking and systematic problem solving. These findings also extend previous evidence by showing that the integration of STEM principles with gamified learning activities can support students in developing more organized reasoning processes while solving flat geometry problems.

The present findings are also consistent with the study conducted by Ajeng Fani Yustina and Yahfizham (2023), which demonstrated that game-based learning media can increase students' interest and engagement in mathematics learning. However, unlike the game-based media developed in their study, the STEM-based Squid Math media was intentionally designed by integrating Science, Technology, Engineering, and Mathematics principles into structured learning activities that actively guide students through mathematical problem-solving processes. This integration may explain the improvement in students' mathematical problem-solving performance observed in the present study. Rather than functioning solely as a motivational tool, the STEM-based Squid Math media provides opportunities for students to develop conceptual understanding and systematic reasoning while solving flat geometry problems.

Furthermore, compared with previous studies that primarily emphasized students' motivation and engagement, the present study provides additional evidence that integrating STEM components into game-based learning can facilitate more structured mathematical problem-solving processes. These findings suggest that the combination of STEM principles and gamified learning not only enhances students' learning engagement but also supports systematic reasoning throughout the problem-solving process.

The findings of the present study further support recent evidence that integrating game-based learning within a STEM framework can enhance students' motivation, focus, and active participation during mathematics learning. In this study, students became more engaged in solving flat geometry problems through contextual challenges and interactive game activities embedded in the STEM-based "Squid Math" media. These findings are consistent with recent studies indicating that gamification in STEM learning positively influences students' engagement, learning outcomes, and mathematical understanding when supported by appropriate instructional design (Arlinwibowo et al., 2025; Mursalin et al., 2024; Wang et al., 2022). Furthermore, the interview findings revealed that students actively explored mathematical concepts, discussed solution strategies, and connected geometry concepts with contextual situations presented in the game. These learning experiences are aligned with the characteristics of STEM education, which emphasize problem solving, creativity, collaboration, and meaningful learning. Therefore, the integration of STEM principles with gamified learning, as implemented in the Squid Math media, provides meaningful opportunities for elementary school students to construct mathematical understanding while strengthening their problem-solving skills.

Moreover, the collaborative elements embedded in the game provide opportunities for students to communicate, exchange ideas, and work together while solving mathematical problems. Such learning experiences are consistent with the characteristics of 21st-century learning, which emphasize communication, collaboration, critical thinking, and problem-solving as essential competencies for students.

This study provides empirical evidence that the STEM-based Squid Math media is an effective instructional approach for improving elementary school students' mathematical problem-solving skills. Through contextual, interactive, and challenging learning activities, students demonstrated a better understanding of flat geometry concepts and were able to apply more systematic problem-solving strategies when solving mathematical tasks. These findings are consistent with recent studies reporting that integrating STEM education with gamified learning enhances students' conceptual understanding, engagement, and mathematical problem-solving performance (Arlinwibowo et al., 2025; Wang et al., 2022). Therefore, the STEM-based Squid Math media can be considered an innovative instructional alternative for supporting meaningful mathematics learning at the elementary school level.

However, several limitations of this study should be acknowledged. First, the sample size was relatively limited, involving only 38 students, which may reduce the generalizability of the findings. Second, the intervention was implemented over a relatively short period, making it difficult to evaluate the long-term effects of the STEM-based Squid Math media. Third, although teacher readiness and competence in implementing STEM-based game learning were not specifically examined in this study, these factors may influence the effectiveness of classroom implementation and should therefore be considered when interpreting the findings.

Therefore, future research is recommended to involve larger and more diverse samples, implement the intervention over longer periods, and examine the effectiveness of the STEM-based Squid Math media across different mathematical topics, grade levels, and educational settings. Future studies may also investigate the long-term retention of students' mathematical problem-solving skills to provide more comprehensive evidence regarding the effectiveness and broader applicability of STEM-based gamified learning.

4. CONCLUSION

Based on the results of data analysis, instrument validation, and statistical testing, it can be concluded that the STEM-based Squid Math game media significantly influenced fifth-grade students' problem-solving abilities. The improvement in the experimental group was shown by the increase in the

mean score from 53.67 in the pre-test to 84.17 in the post-test. Meanwhile, the control group, which received instruction through the Project-Based Learning (PjBL) approach, experienced a lower improvement, with the average score rising from 41.26 to 61.85. In addition to the test scores, the level of learning implementation also supported the effectiveness of the instruction. The experimental group obtained an implementation score of 100%, while the control group achieved 95%. This difference shows that STEM-based learning using the Squid Math game was carried out more optimally than the PjBL approach.

The Independent Samples T-Test results produced a significance value of $p = 0.000$, which was below 0.05. This result shows that there was a statistically significant difference in students' problem-solving abilities between the two groups. Therefore, the alternative hypothesis (Ha) was accepted, indicating that the Squid Math game media was effective in enhancing students' problem-solving skills. Overall, the integration of STEM-based learning with educational game media created a learning experience that was more interactive, attractive, and meaningful. Thus, Squid Math media can be recommended as an innovative alternative for improving the quality of mathematics learning in elementary schools.

From a practical point of view, the findings of this study have important implications for teachers in applying innovative learning strategies. Squid Math media can be adjusted to various classroom contexts by modifying the difficulty level, learning objectives, and students' characteristics. Teachers can integrate this game into regular classroom learning, group discussions, or problem-solving activities to increase students' engagement and participation. Furthermore, the use of this media encourages teachers to implement more interactive and student-centered learning approaches, which are important elements of 21st-century education.

From a theoretical point of view, this study contributes to the development of STEM-based game learning models, particularly in elementary geometry learning. The integration of STEM components with gamified learning through culturally relevant media such as Squid Math provides a more comprehensive framework for improving students' problem-solving abilities. In addition, this study strengthens the idea that combining interdisciplinary learning with game elements can enhance both the cognitive and affective dimensions of the learning process.

Suggestions for Further Research

This study has several limitations; therefore, further research is recommended to extend and enrich the present findings. Future studies may investigate the application of the STEM-based *Squid Math* media to other mathematical topics, such as algebra, fractions, or measurement, in order to evaluate its effectiveness across a wider range of content areas. In addition, subsequent research could develop digital or technology-enhanced versions of the game to improve its accessibility and scalability in diverse educational contexts. It is also advisable to involve larger and more heterogeneous samples and to implement the intervention over a longer period so that more comprehensive and generalizable findings can be obtained.

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