

THE EFFECT OF CONCEPTUAL UNDERSTANDING ON MATHEMATICAL PROBLEM-SOLVING SKILLS IN GAMIFICATION LEARNING

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ABSTRACT

Indonesian students' mathematical problem-solving abilities are still relatively low, partly due to their weak conceptual understanding. A teaching model capable of enhancing student motivation and understanding of mathematical concepts is needed. This study aims to determine the relationship between conceptual understanding and mathematical problem-solving abilities through gamification-based learning. The study was conducted at MTs Negeri 3 Serang in the 2024/2025 academic year, involving 58 eighth-grade students, divided into two groups: the experimental class (VIII A) and the control class (VIII C). The method used was a quasi-experimental study with a pretest-posttest control group design. The research instruments consisted of a conceptual understanding test and a mathematical problem-solving test on the topic of Systems of Linear Equations. The results showed a significant difference between the experimental and control classes. Students learning with the gamification model achieved a higher average increase in post-test scores compared to those using the conventional method. This demonstrates that gamification has a positive impact on conceptual understanding and problem-solving skills. However, the Pearson correlation results showed no significant relationship between conceptual understanding and problem-solving abilities in gamified learning. These findings confirm that while gamification can improve learning outcomes, problem-solving skills also influence other factors such as critical thinking, creativity, and motivation. Thus, gamification can be used as an alternative.

Keywords: conceptual understanding; gamification; mathematical problem-solving ability

ABSTRAK

Kemampuan pemecahan masalah matematis siswa di Indonesia masih tergolong rendah, salah satunya karena lemahnya pemahaman konsep dalam pembelajaran. Diperlukan model pengajaran yang mampu meningkatkan motivasi serta pemahaman siswa terhadap konsep matematika. Penelitian ini bertujuan mengetahui hubungan antara pemahaman konsep dan kemampuan pemecahan masalah matematis melalui pembelajaran berbasis gamifikasi. Penelitian dilaksanakan di MTs Negeri 3 Serang tahun ajaran 2024/2025 dengan melibatkan 58 siswa kelas VIII, terbagi dalam dua kelompok: kelas eksperimen (VIII A) dan kelas kontrol (VIII C). Metode yang digunakan adalah quasi-eksperimen dengan desain pretest-posttest control group. Instrumen penelitian berupa tes pemahaman konsep dan tes pemecahan masalah matematika pada materi Sistem Persamaan Linear. Hasil penelitian menunjukkan adanya perbedaan yang signifikan antara kelas eksperimen dan kontrol. Siswa yang belajar dengan model gamifikasi memperoleh peningkatan rata-rata nilai post-test yang lebih tinggi dibandingkan metode konvensional. Hal ini membuktikan bahwa gamifikasi memberikan dampak positif terhadap pemahaman konsep dan keterampilan pemecahan masalah. Namun, hasil korelasi Pearson yang ditampilkan tidak terdapat hubungan yang signifikan antara pemahaman konseptual dan kemampuan pemecahan masalah dalam pembelajaran gamifikasi. Temuan ini menegaskan bahwa meskipun gamifikasi dapat meningkatkan hasil belajar, kemampuan

memecahkan masalah juga mempengaruhi faktor lain seperti pemikiran kritis, kreativitas, dan motivasi. Dengan demikian, gamifikasi dapat dijadikan alternatif.

Kata kunci: *gamifikasi; kemampuan pemecahan masalah matematis; pemahaman konseptual*



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Introduction

Mathematics education plays an important role in shaping logical, analytical, critical, and creative thinking skills. A primary goal of learning mathematics is for students to grasp concepts and apply their understanding to resolve issues in different real-life situations. Nonetheless, in practice, the mathematical problem-solving abilities of Indonesian students remain quite low. According to the findings of the 2015 Programme for International Student Assessment (PISA) survey, Indonesia was placed 69th among 76 nations in mathematics (Hidayat et al., 2022). These results indicate that many students still have difficulty understanding basic concepts and applying them to solve mathematical problems.

In 21st century learning, the goal of mathematics education is for students to possess the 4Cs, which incorporate analytical reasoning and issue resolution, originality and inventiveness, interaction, along with teamwork. According to NCTM (2000), there are five process standards in mathematics to achieve mathematics learning objectives, namely addressing issues, logical thinking and justification, interaction, links, and depiction (Garcia et al., n.d.) .This condition shows that the learning process that takes place in the classroom does not fully emphasize the development of conceptual understanding but focuses more on the delivery of procedures and formulas.

Conceptual understanding is the ability to understand ideas, principles, and relationships between mathematical concepts (Martin et al., 2023). Mathematical conceptual understanding is when students are able to understand and explain the concepts they have learned (Septiani & Pujiastuti, 2020). Learners who possess a strong grasp of concepts will have the ability to showcase ideas through different types of mathematical expression, relate one concept to another, and use them in problem solving (Febriantika, 2020; Nurani et al., 2021). According to Marufi et al. (2018), Students are considered to grasp a concept if they can explain mathematical ideas in their own words and relate them to relevant situations. Therefore, conceptual understanding is the main foundation for building mathematical problem-solving skills.

Problem solving lies at the heart of mathematics education, with a significant connection between students' beliefs, their problem-solving actions, and their academic success (Zayyadi, 2019). Problem solving is an essential component of the math curriculum as it allows students to apply their gained knowledge and abilities in addressing unique challenges (Nuramalina et al., 2020). With good problem-solving skills, students are able to gain experience in using their existing knowledge and skills to solve non-routine problems. When ideas and processes are disconnected, students might possess a strong intuitive grasp of mathematics but fail to solve problems, or they might produce answers without comprehending their actions (Hiebert, 2019). The current findings emphasize the causal, two-way

connections between conceptual and procedural knowledge in children acquiring mathematical equivalence (Rittle-Johnson & Alibali, 1999).

Earlier research has investigated attempts to enhance conceptual comprehension and problem-solving abilities using creative learning models. Gamification modifies learning by including images and conversations (Winarto et al., 2023). (Fitriani, 2020) found that the use of gamification-based teaching grounded in practical examples can enhance students' grasp of mathematical ideas. Setiawan (2022) demonstrated that the gamification-oriented Search, Solve, Create, and Share (SSCS) framework can enhance students' grasp of concepts and learning engagement (Niko, 2021). Meanwhile, proved that gamification-based Project-Based Learning (PjBL) is successful in enhancing mathematical problem-solving abilities. From these studies, it can be concluded that gamification has great potential in encouraging student engagement and strengthening the learning process (Rofiqoh, 2021).

However, previous studies have generally only emphasized the effect of gamification on improving student learning outcomes or motivation, while the connection between conceptual comprehension and problem-solving abilities in mathematics context of gamified learning has not been widely studied. This is where the originality of this research resides, in that it not only compares the effectiveness of gamification with conventional learning, but also analyzes the influence of conceptual comprehension regarding students' mathematical problem-solving skills in gamified learning frameworks. Thus, this study attempts to fill the research gap regarding the connection between these two factors within the framework of gamification.

Field evidence shows that at MTs Negeri 3 Serang, many students have difficulty understanding basic mathematical concepts, especially on the topic of Two-Variable Linear Equation Systems (SPLDV). Students frequently memorize formulas without grasping their conceptual significance, which hinders their ability to apply these concepts in solving problem-based questions. This shows the necessity for a learning method that can enhance student motivation, involvement, and comprehension of fundamental mathematical concepts (Dwita Imannia et al., 2022). As a solution, the implementation of gamification-based learning can be an innovative alternative. Gamification adds game components like points, levels, and rewards into education to enhance student involvement, motivation, and pleasure (Krath et al., 2021; Aldalur & Perez, 2023). Sebastian Deterding defines gamification as incorporating game design elements into non-gaming settings (Deterding et al., 2018).

In this study, Wordwall and Google Sites applications were used to support the implementation of gamification. Wordwall was chosen because it is capable of providing interactive game-based learning activities such as quizzes, puzzles, and matching games that give immediate feedback to students. This is in line with the principle of constructivism, where students build their understanding through active learning experiences. Meanwhile, Google Sites was used as a medium for integrating learning activities, where students could independently access learning materials, assignments, and reflections. This feature supports the concept of Blended Learning and Student-Centered Learning, where learners take an active part in controlling their own educational journey. By utilizing these two platforms,

mathematics learning not only becomes more interesting and enjoyable, but also enables interaction, reflection, and the formation of deeper conceptual meaning. Therefore, the application of gamification based on Wordwall and Google Sites is expected to strengthen conceptual understanding while enhancing students' abilities in solving mathematical problems (Astuti et al., 2022).

In light of the aforementioned details, this study seeks to: Assess the impact of gamified learning on students' comprehension of concepts and their abilities in solving mathematical problems, and analyze the relationship between conceptual understanding and skills in solving mathematical problems of students who learn using the gamification model. The findings of this research are expected to contribute theoretically towards the advancement of more interactive and meaningful mathematics learning, as well as serve as a reference for teachers in choosing innovative learning strategies that can improve students' 21st-century skills.

Research Methods

Assess the impact of gamified learning on students' grasp of concepts and their capability to resolve mathematical issues, and the anticipated outcomes of this research are that this investigation employs a quasi-experimental approach. This research will employ an experimental framework consisting of two groups, specifically a setup of control group with pre-test and post-test. The first group is referred to as the experimental group, receiving gamification-based learning via Wordwall and Google Sites, while the second group is known as the control group, which does not utilize the gamification learning model. Table 1 below shows the pretest-posttest control group design. This study contributes theoretically to the development of more interactive and meaningful mathematics learning and serves as a reference for teachers in choosing innovative learning strategies that can improve students' 21st-century skills.

Table 1. Research design

Class Group	Pre-test	Treatment	Posttest
Experimental	O_1	X	O_2
control	O_3		O_4

Source: (Sugiyono, n.d.)

Explanation :

O_1 = Pre-test given to the experimental class

O_2 = Posttest given to the experimental class

O_3 = Pre-test given to the control class

O_4 = Posttest administered to the control class

The subjects in this research were composed of every eighth-grade students at MTS Negeri 3 Serang during the 2024/2025 academic year. The method applied purposive sampling (classes were chosen based on specific criteria, such as parity in academic performance). Two classes were selected, namely class VIII A with 29 samples as the experimental class using gamification teaching materials using Wordwall and Google Sites, and class VIII C with 29 samples as the control class using conventional learning. The research instruments used in this study were conceptual understanding and mathematical problem-solving ability tests, teaching

modules, with 8 sessions on SPLDV material, 6 sessions for learning, and 2 other sessions for pre-tests and post-tests.

Conceptual understanding indicators include; (1) Repeating concepts; (2) Grouping objects based on specific properties; (3) Presenting concepts in various mathematical representations; (4) Grouping concepts or algorithms in problem solving. (Gee & Harefa, 2021). Meanwhile, indicators of mathematical problem solving include; (1) Understand the problem; (2) Make a plan; (3) Implement the plan; (4) Evaluate (Rahmawati et al., 2021). SPSS 27 for Windows is used to characterize the data.

This study uses Hypothesis Testing to examine the variations among the experimental group and the control group, and Pearson's correlation test to examine the relationship between variables. Prerequisite tests were conducted before performing the hypothesis test, namely Normality and Homogeneity tests. The Shapiro-Wilk test for normality was conducted, with the rule that if $p > 0.05$, then H_0 is rejected, whereas if $p < 0.05$, then H_0 is accepted. In this study's homogeneity test, the Levene test was employed with a significance level of $p > 0.05$, where the decision criteria state that if $p > 0.05$, then H_0 is accepted, and if $p < 0.05$, H_0 is rejected. The following are the hypotheses: 1) There exist variations in conceptual understanding and mathematical problem-solving abilities among students based on variable factors. 2) There is a mportant connection between conceptual comprehension and mathematical problem-solving ability in the post-test of the experimental class.

Results and Discussion

Result

Table 2 displays the findings of the descriptive analysis test.

Table 2. Descriptive statistics

	N	Min	Max	Mean	Std. Deviation
Pre-test Experiment	29	6	31	16,84	6,586
Post-test Experiment	29	34	100	59,62	15,715
Pre-test Control	29	0	31	16,16	7,703
Post-test Control	29	19	81	48,41	14,973

Source: compiled from research data, 2025

According to the findings in Table 2, the total number of students in the experimental and control groups was 29. The experimental group's mean results for the pre-exam and post-exam are noted as 16.84 and 59.62, while the control group's mean pretest and posttest scores are 16.16 and 48.41. Judging from the pretest results of the two classes, there is no significant difference in scores, so it can be assumed that the two classes have balanced abilities. Meanwhile, the difference in the post-test average scores between the two classes suggests that there is a difference in conceptual understanding and mathematical problem-solving abilities. Furthermore, the data was analyzed for normality using Kolmogorov-Smirnov to analyze whether the population studied was typically distributed or not.

Based on Table 3, the significant values of the pretest for Conceptual Understanding in the experimental class and control class were 0.918 and 0.279, respectively, which means $sig. > \alpha = 0.05$, so H_0 is rejected. The significance values

for the posttest Conceptual Understanding in both classes were 0.862 and 0.279, respectively, which means $\text{sig.} > \alpha = 0.05$, so H_0 . This shows that the pretest and posttest data for conceptual understanding in both classes are normally distributed. Table 3, presents the normality test.

Table 3. Normality test for conceptual understanding

Conceptual Understanding	Class	One-Sample Kolmogorov-Smirnov Test		
		Statistic	df	Sig.
	Pre-test Experiment	0,098	29	0,918
	Post-test Experiment	0,107	29	0,862
	Pre-test Control	0,179	29	0,279
	Post-test Control	0,179	29	0,279

Source: compiled from research data, 2025

Based on Table 4, the significant results of the pretest for Mathematical Problem Solving Skills in the experimental group and control group were 0.478 and 0.317, respectively, which means $\text{sig.} > \alpha = 0.05$, so H_0 is rejected. The significance values for the posttest Mathematical Problem Solving Ability in both classes were 0.513 and 0.268, respectively, which means $\text{sig.} > \alpha = 0.05$, so H_0 . This indicates that the pretest and posttest results for conceptual understanding in both classes follow a normal distribution. Table 4, displays the findings of the research.

Tabel 4. Normality test for mathematical problem-solving ability

Mathematical Problem-Solving Ability	Class	One-Sample Kolmogorov-Smirnov Test		
		Statistic	df	Sig.
	Pre-test Exsperiment	0.151	29	0,478
	Post-test Exsperiment	0,147	29	0,513
	Pre-test Control	0,172	29	0,317
	Post-test Control	0,180	29	0,268

Source: compiled from research data, 2025

As the tested data follows a normal distribution, a homogeneity test will be performed. Table 5 presents the outcomes of the homogeneity test.

Table 5. Homogeneity test

	Levene Statistic	df1	df2	Sig.
<i>Based on Mean</i>	0,011	1	56	0,918
<i>Based on Median</i>	0,001	1	56	0,971
<i>Based on Median and with adjusted df</i>	0,001	1	55,621	0,971
<i>Based on trimmed Mean</i>	0,023	1	56	0,879

Source: compiled from research data, 2025

Based on Table 5, the significance value derived from the mean is 0.918, exceeding $\alpha = 0,05$, thus it can be inferred that the data is homogeneous. Because the data is homogeneous, further tests can be carried out, namely data hypothesis

testing and Pearson's correlation test. Hypothesis testing is conducted to test whether the proposed hypothesis is accepted or rejected. If $sig. > \alpha$ than H_0 is accepted.

The data hypothesis is :

H_0 : There is no difference in conceptual understanding and mathematical problem-solving abilities among students based on factor variables.

H_1 : there are differences in conceptual understanding and mathematical problem-solving abilities among students based on variable factors.

The results of the study are presented in Table 6.

Table 6. Data hypothesis test

<i>t</i>	<i>df</i>	<i>Sig. (2-tailed)</i>	<i>Mean Difference</i>	<i>Std. Error Difference</i>
-17,069	28	0,000	-42.759	2.505

Source: compiled from research data, 2025

Based on Table 6, the significance value of the data is less than $\alpha = 0,05$, namely 0,000, which means that H_0 is rejected. Thus, it can be concluded that the average conceptual understanding ability in mathematical problem solving of students given the gamification learning model is higher than that of students given the conventional learning model (discovery learning). Therefore, the gamification learning model has a positive effect on developing the conceptual understanding of students at MTs Negeri 3 Serang.

Hypothesis 2 :

H_0 : There was no significant relationship between conceptual understanding and mathematical problem-solving ability in the post-test of the experimental class.

H_1 : There is a significant relationship between conceptual understanding and mathematical problem-solving ability in the post-test of the experimental class.

Pearson's correlation test was used to measure hypothesis 2, to examine the link between conceptual comprehension and students' ability to solve mathematical problems abilities on the post-test scores of the experimental class (gamification-based learning). The decision criteria for the Correlation Test are based on the significance value and Pearson correlation. If $r_{hitung} > 0.05$, then H_0 is accepted, and if $r_{hitung} < 0.05$, then H_0 is rejected. The following are the guidelines for the degree of *Pearson correlation* in Table 7.

Coefficient Interval	Correlation Strength
0,00-0,20	Very Weak
0,21-0,40	Weak
0,41-0,70	Moderate
0,71-0,90	Strong
0,91-0,99	Very Strong
1	Perfect Correlation

Based on Table 8, the correlation test result are as follows:

Table 8. Pearson correlation test for posttest of the exsperimental class

		Conceptual Understanding	Problem-Solving Ability
Conceptual Understanding	Pearson Correlation	1	.343
	Sig. (2-tailed)		.069
	N	29	29
Problem-Solving Ability	Pearson Correlation	.343	1
	Sig. (2-tailed)	.069	
	N	29	29

Source: compiled from research data, 2025

From the research results table 8, the Pearson the relationship between conceptual understanding and problem-solving skills was 0.343. Based on the Pearson correlation degree guidelines, the post-test in this experiment showed a weak correlation with a positive relationship. The 2-tailed Sig. value was greater than $\alpha = 0,05$, namely 0.069, which means that H_0 is accepted. This indicates that there is no substantial connection between conceptual understanding and mathematical problem-solving skills in the post-test of the experimental group.

Discussion

The findings of the research indicate that gamification-based learning has a positive effect on enhancing students' comprehension of concepts and their ability to address mathematical issues. These findings are consistent with findings emphasizing that students' use of and shift between different representations during problem solving plays an important role in building conceptual understanding (Jäder & Johansson, 2025). In the local context, studies on the effectiveness of gamification can increase student motivation and engagement, which are important factors in this research (Satriawan & Abdullah, 2016). Although the methods differ, the study (Ningsih et al., 2022) showing that strategies that integrate real-world contexts with learning can strengthen conceptual understanding. Furthermore, ZDM's review "Problem solving in mathematics education: tracing its foundations and current research-practice trends" (2024) underscores the importance of problem solving in mathematics education and makes this research relevant to contemporary trends in mathematics research (Santos-Trigo, 2024).

This can be seen from the statistical test results, which show a significant difference between classes taught using gamification and classes taught conventionally. Students who participated in gamified learning obtained higher posttest scores than pupils in the control group. This improvement indicates that the application of game elements such as points, rankings, and challenges in Wordwall and Google Sites media can increase student engagement, motivation, and learning outcomes. Nonetheless, the outcomes of the correlation tests suggest that there exists no significant link between conceptual understanding and mathematical problem-solving abilities in the gamification class. This means that an increase in conceptual understanding does not always go hand in hand with students' ability to solve mathematical problems.

Several factors that influence these results include increased student motivation, a more engaging learning environment, and immediate feedback that helps students correct their mistakes quickly (Handoko et al., 2021). Gamification provides an active and interactive learning experience that encourages students to participate more in each stage of learning. In addition, digital media such as Wordwall and Google Sites provide a variety of fun learning activities and support concept mastery through educational games. However, because gamification tends to focus students on achieving scores and winning games, reflection on problem-solving strategies is not yet optimal. This may lead to the connection between conceptual understanding and problem-solving abilities not being firmly established.

This study has several advantages, including the use of a quasi-experimental design with a control group so that the results of the comparison can be measured objectively. The application of gamification using Wordwall and Google Sites is also in line with the characteristics of 21st-century students who are familiar with digital technology. In addition, this study measures two important abilities in mathematics learning, namely conceptual understanding and problem-solving skills, thus providing a more comprehensive picture of the effect of gamification on learning outcomes. However, this study also has limitations because it was only conducted in one school with a limited sample size and on SPLDV material, so the results cannot be generalized widely. Furthermore, the study did not explore students' thinking processes in depth, so it did not fully describe the connection between conceptual comprehension and problem-solving abilities.

The results of this study align with the outcomes of earlier research. Fitriani (2020) discovered that employing gamification in teaching materials can enhance students' comprehension of mathematical concepts because it fosters motivation and active participation in learning. Setiawan's (2022) research also shows that the gamification-based SSCS learning model can increase student activity and conceptual understanding, while Andriani et al. (2021) state that the use of Wordwall is effective in building conceptual understanding through enjoyable learning experiences. However, these research results differ from the findings of Zayyadi (2019) and Hidayat et al. (2022), that demonstrate a notable connection between conceptual comprehension and abilities in solving mathematical problems. This discrepancy can be explained by the fact that in gamified learning, students tend to focus on achieving points or winning the game, thus limiting the time for reflection and analysis of problem-solving strategies.

Based on constructivism theory, gamified learning provides space for students to construct their own knowledge through exploratory activities and social interaction. Students do not just passively receive information, but actively participate, try, and correct mistakes (Sanchez et al., 2020). This strengthens conceptual understanding because students experience the mathematical thinking process themselves. The results of this study also support the Self-Determination theory proposed by Deci and Ryan (2000), which emphasizes that when basic psychological needs such as autonomy, competence, and relatedness are met, students' intrinsic motivation will increase. Gamification elements such as point systems, challenges, and rankings are able to meet these needs, thereby encouraging greater engagement and better learning outcomes. Moreover, the findings of this

research are similarly consistent with the NCTM (2000) process standards, which emphasize the importance of problem solving, reasoning, communication, connection, and representation in mathematics learning. Through gamification, students can develop these five aspects in a more enjoyable way.

After the implementation of gamification, students showed high enthusiasm in learning mathematics. They were more active in answering questions, doing exercises, and explaining the concepts they had learned. Students also found it easier to understand SPLDV concepts through various representations, such as graphs and algebraic forms. However, even though conceptual understanding improved, the connection between conceptual comprehension and problem-solving skills was not significant. This shows that improved conceptual ability does not necessarily improve students' ability to solve complex problems. Based on learning transfer theory, this can be explained by the fact that conceptual understanding needs to be practiced contextually in order to be transferred to real problem-solving situations. Therefore, the application of gamification should be combined with a problem-based learning approach to strengthen students' reflective abilities in applying concepts to new situations.

Theoretically, this research adds to the development of learning theories based on motivation and active participation. Gamification has been proven to establish an enjoyable educational atmosphere, encourage student participation, and assist them in developing conceptual comprehension. Practically, the findings of this research offer alternative effective mathematics learning strategies to improve students' understanding and higher-order thinking skills. Teachers are advised to utilize gamification elements such as points, challenges, and rankings in learning activities, as well as adding reflection sessions so that students are not only oriented towards the results of the game, but also understand the thinking process behind it. Thus, mathematics learning can become more interesting, meaningful, and oriented towards the enhancement of analytical reasoning abilities and efficient issue resolution.

Conclusion and Suggestion

From the findings of data examination and conversation, it can be inferred that gamified learning has a positive effect on improving conceptual comprehension and math problem-solving abilities in middle school students. Students taught using gamification showed higher learning outcomes compared to students taught conventionally. This proves that the integration of game elements such as points, rankings, and challenges in Wordwall and Google Sites media can increase student engagement, motivation, and understanding of mathematical concepts.

A significant link exists between conceptual comprehension and students' mathematics problem-solving skills in gamified education. This means that although both abilities improved, conceptual understanding did not directly contribute to students' ability to solve mathematical problems. This condition indicates that in addition to conceptual understanding, problem-solving abilities are also influenced by other factors such as critical thinking, learning experiences, and strategy reflection.

This study reinforces the theories of constructivism and self-determination, in which knowledge is actively constructed through meaningful learning

experiences, and Intrinsic motivation rises when the requirements for independence, skill, and relationship are satisfied. In theory, the findings of this research aid in advancing motivation-driven learning and engaged involvement. Practically, these findings provide alternative interactive and enjoyable mathematics learning strategies that are in line with the characteristics of the digital generation.

Therefore, gamified learning can serve as a creative method to enhance the quality of mathematics education in schools. For optimal results, teachers are advised to combine gamification with problem-based approaches or conceptual reflection so that students not only understand the concepts but are also able to apply them in solving problems critically and creatively.

Second, to optimize the connection between conceptual comprehension and problem-solving abilities, teachers need to add reflection activities, strategy discussions, and contextual exercises after students complete the game. That way, students don't just focus on earning points, but also understand the reasoning and concepts behind problem-solving steps.

Third, future researchers are expected to develop this study by involving a broader and more diverse sample and integrating qualitative analysis of students' thinking processes. Future research is also recommended to combine gamification with other learning models, such as Problem-Based Learning or Discovery Learning, so that the connection between conceptual understanding and problem-solving skills can be built more strongly.

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