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The Effect of a Quizizz Assisted Gamified Learning Model on the Mathematical Problem-Solving Skills of 10th-Grade High School Students

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Abstract

The research aims to find out the effect of the gamification learning model using Quizizz on students' mathematical problem-solving ability that focuses on Systems of Linear Equation Problems with Three Variables (SPLTV). This research used a quantitative method with a quasi-experimental design of nonequivalent control groups. The population was 660 tenth-grade students in MAN 2 Model Medan in the 2025/2026 academic year. Purposive sampling was used to take Class X-Q (n=32) as the experimental group and Class X-R (n=30) as the control group. Nine validated essay items (four pretest and five posttest questions) were used for data collection and met all standard psychometric criteria for validity, reliability, difficulty level, and discrimination index. Pre-analysis assumptions were satisfied, with the Shapiro–Wilk test confirming a normal distribution (0.202, 0.486, 0.172, and 0.133) and Levene's test demonstrating variance homogeneity (0.414). The independent samples t-test revealed a statistically significant difference ($p = 0.002 < 0.05$), with the calculated t-value ($t = 3.22$) exceeding the critical t-threshold (2.000). Furthermore, the experimental cohort achieved a higher posttest mean score (86.78) than the control cohort (81.43), yielding a substantial effect size (Cohen's $d = 0.819$). These outcomes indicate that integrating gamification via Quizizz substantially enhances students' mathematical problem-solving skills. The distinct novelty of this research lies in implementing this digital gamification framework for SPLTV instruction while assessing problem-solving performance through Polya's framework. Future investigations are encouraged to extend this model to alternative mathematical topics, diverse educational levels, or additional learning variables.

Keywords: gamification, Quizizz, mathematical problem-solving, SPLTV, senior high school students.

1. Introduction

Education is a process directed towards the optimum development of the potential of the students in the cognitive, affective and psychomotor domains. Educational experiences should enable students to think logically, critically, creatively and systematically when faced with various life challenges. Mathematics is one of the subjects that have an important role in the development of these abilities. Mathematics is not only a tool to understand concepts and computational procedures, but also a means to develop higher order thinking skills especially students' ability to solve mathematical problems (Setiyani et al., 2020). The capacity to resolve mathematical problems represents a fundamental learning objective that students are anticipated to master in mathematics education. Such ability holds significance because it allows students to comprehend problems, formulate strategies for resolution, execute solution procedures in a structured manner, and reflect upon the outcomes achieved. According to Polya (1973), proficiency in mathematical problem-solving is characterized by four core stages: comprehending the problem, formulating a strategy, executing the plan, and reviewing the outcomes. These four indicators are interrelated stages that form the foundation of students' success in solving mathematical problems.

The results of the OECD's 2022 Programme for International Student Assessment (PISA) demonstrate Indonesian pupils' poor understanding of mathematics problem-solving techniques. Indonesia's average mathematics score in this evaluation was 366, which is much lower than the OECD average of 472. In addition, merely 18% of students from Indonesia managed to attain the minimum competency threshold (Level 2) in mathematics, in contrast to the OECD average of 69%. The findings showed that a large number of students have dificulty applying mathematical problem-solving concepts to solve problems in different real life situations. Such a scenario underscores the urgent need for pedagogical approaches that can effectively boost students' mathematical problem-solving proficiency. Such a scenario underscores the urgent need for pedagogical approaches that can effectively boost students' mathematical problem-solving proficiency. This emphasis aligns with the National Council of Teachers of Mathematics (NCTM, 2000), which asserts that problem-solving serves as the centerpiece of mathematics education, as it fosters the development of critical thinking, mathematical reasoning, communication skills, and logical decision-making. Accordingly, the teaching of mathematics needs to extend beyond the mere mastery of formulas and procedural steps, but should also grant students sufficient opportunities to cultivate their problem-solving abilities to their fullest potential. Nevertheless, findings from a range of studies indicate that student's competence in resolving mathematic problems continues to be relatively poor. Astuti et al. (2022) noted that students often struggle to understand word problems, construct mathematical models, determine solution strategies, and verify their answers. These outcomes align with the research by Nabila et al. (2025), which demonstrates that students limited mathematical problem-solving capabilities are reflected in their difficulties integrating provided data with appropriate mathematical concepts during problem-solving.

This issue was also identified using the results of the researcher's observations and discussions with math teachers of 10th-grade students at MAN 2 Model Medan. Based on the interview results, the teachers explained that students' understanding of the material presented and the issues posed in word problems on the subject of Systems of Linear Equations with Three Variables (SPLTV) fell into the "fairly good" category. Furthermore, the majority of students were able to identify the proper solution technique, whether it was replacement, elimination, or a mix of the two. These results show that the majority of students have developed the Polya-defined markers of problem comprehension and solution planning quite successfully. However, the teacher noted that there are still some students who struggle to transform contextual problems into mathematical models of SPLTV. These difficulties indicate that students are not yet fully able to connect the information in word problems with appropriate mathematical representations. In fact, the ability to represent problems as mathematical models is a crucial stage in the problem-solving process, given that it functions as the basis for identifying the correct solution strategy (Kania & Ratnawulan, 2022). Furthermore, regarding the indicator of implementing a solution plan, there are still students who require guidance in completing exercises independently and systematically. The teacher also explained that the most common mistake students make when solving problem-solving questions on the SPLTV material is a lack of thoroughness in the process of eliminating numbers or variables. This mistake causes students to obtain inaccurate results even though the strategies they used were correct. This situation indicates that students' proficiency in the "implementing a solution plan" indicator still needs to be improved.

Gamification offers one possible approach to addressing this issue. It refers to the use of game-design elements in non-game contexts to shape learners' experiences and engagement (Deterding et al., 2011). In education, points, challenges, rankings, rewards, and feedback can be integrated into learning activities to encourage participation. However, gamification should not be assumed to produce positive learning outcomes automatically. A meta-analysis by Sailer and Homner (2020) found that gamification can have a moderate positive effect on learning, but its effectiveness depends on how game elements are designed and connected to instructional objectives. Similarly, Oliveira et al. (2023) emphasized the need for stronger empirical evidence and more context-specific research because the effects of gamification may vary according to the learners, learning activities, and implementation strategies. Quizizz is one digital platform that can support the implementation of gamification in mathematics learning. Its interactive features, including scores, rankings, challenges, and immediate feedback, can be incorporated into learning activities to encourage student participation. However, Quizizz should not be considered merely a digital quiz or assessment tool. Its educational value depends on how it is integrated into a broader instructional model. When combined with a gamification-based learning model, Quizizz can be used to present challenges, provide feedback, encourage participation, and support students' continued engagement with mathematical tasks.

Previous studies have reported positive findings regarding the use of Quizizz in mathematics education. Setiyani et al. (2020) found that Quizizz-supported learning could contribute to students' mathematical problem-solving skills. Other studies have also reported positive effects of Quizizz on mathematical abilities, student motivation, and learning engagement (Astuti et al., 2022; Safriana et al., 2025). Nevertheless, these findings remain context-dependent because previous studies have differed in terms of instructional models, mathematical topics, research designs, instruments, and learning outcomes. Therefore, the specific contribution of Quizizz-assisted gamification to mathematical problem solving cannot be determined solely from the positive results of previous studies. This situation reveals several research gaps. Theoretically, previous studies have not sufficiently explained how gamification-assisted digital learning can support the different stages of mathematical problem solving. Methodologically, many studies have focused on overall achievement, motivation, engagement, or total problem-solving scores, while detailed analyses based on the four stages of Polya remain limited. Moreover, differences in research designs and instructional contexts make it difficult to determine whether the observed effects are attributable to the digital platform, the instructional model, or the interaction between both factors. Contextually, research examining a Quizizz-assisted gamification learning model for senior high school students learning Systems of Linear Equations with Three Variables (SPLTV) remains limited. This topic is important because SPLTV requires students to interpret contextual information, construct mathematical models, select appropriate strategies, perform algebraic procedures accurately, and verify their solutions.

The present study addresses these gaps by examining the effect of a Quizizz-assisted gamification learning model on students' mathematical problem-solving skills in SPLTV. A quasi-experimental Nonequivalent Control Group Design was used to compare an experimental group receiving Quizizz-assisted gamification learning with a control group receiving conventional instruction. In addition to examining differences in overall posttest performance, this study analyzes students' problem-solving abilities according to Polya's four indicators and reports the practical magnitude of the treatment through Cohen's d effect size. Accordingly, the study does not merely examine whether Quizizz is effective, but also provides a more detailed account of students' performance across the stages of mathematical problem solving. The novelty of this study lies in the integration of a Quizizz-assisted gamification learning model, a quasi-experimental comparison between experimental and control groups, and an indicator-level analysis based on Polya's framework in the context of SPLTV. The findings are expected to provide a practical alternative for mathematics teachers seeking to design more interactive learning environments that encourage active participation, problem-solving practice, and immediate feedback. The results may also serve as a basis for future research examining other digital gamification platforms, different mathematical topics, or student-related factors that may influence the effectiveness of gamification in mathematics education. Therefore, this study aims to determine the effect of a Quizizz-assisted gamification learning model on the mathematical problem-solving skills of senior high school students in learning Systems of Linear Equations with Three Variables (SPLTV).

2. Methods

This research adopted a quantitative approach through the application of a quasi-experimental method. Such a method was employed to assess the impact of a given intervention under circumstances where complete randomization of research subjects could not be carried out. As a result, the classes involved in this study consisted of groups that had already been formed beforehand (Pardede et al., 2022). The Nonequivalent Control Group Design, which combines two separate groups an experimental group and a control group was the research method used in this investigation. Both groups took a pretest to gauge students' starting proficiency before the intervention was implemented. After that, the control group received traditional training while the experimental group received instruction utilizing a gamification-based paradigm backed by Quizizz. Following the completion of the teaching process, a posttest was given to both groups to gauge the students' aptitude for solving mathematical puzzles. Because it allows researchers to analyze and evaluate the effects of an intervention between two groups even in the absence of subject randomization, this specific design is frequently used in educational research (Rahmawati, 2022; Silaban et al., 2022).

The following is an illustration of the research design.

Group	Pretest	treatment	Posttest
Experimental	O_1	X	O_2
Control	O_3	–	O_4

Notes:

O_1 = pretest for the experimental class

O_2 = posttest for the experimental class

O_3 = pretest for the control class

O_4 = posttest for the control class

X = Quizizz-assisted gamified learning model

– = conventional learning

This research was carried out at MAN 2 Model Medan throughout the even semester of the 2025/2026 academic year. The population involved in this study encompassed the entire 10th-grade student body at MAN 2 Model, amounting to 660 students distributed across 20 classes. The sampling technique applied was purposive sampling, a method in which sample selection is based on particular considerations tailored to the requirements of the research (Sugiono, 2022). Through this technique, Class X-Q was designated as the experimental class, comprising 32 students, while Class X-R served as the control class, comprising 30 students. The selection of this technique took into account the relatively similar characteristics shared by both classes, as well as recommendations provided by the subject teachers, thereby ensuring consistency with the objectives of the research (Pardede et al., 2022).

The research instrument was an essay-based test designed to measure students' mathematical problem-solving ability based on Polya's (1973) four indicators: understanding the problem, devising a plan, carrying out the plan, and looking back. Prior to administration, the instrument underwent expert validation and item analysis, including Pearson product-moment validity testing, Cronbach's alpha reliability testing, item difficulty analysis, and discrimination analysis. Items that did not meet the validity criteria were excluded, resulting in a final instrument consisting of nine items: four pretest items and five posttest items, all of which represented the four mathematical problem-solving indicators. Data were collected through a pretest to identify students' initial abilities and a posttest to measure their abilities after the instructional intervention (Purwadi, 2022). The data analysis began with descriptive statistics, followed by the Shapiro–Wilk normality test and Levene's homogeneity test as statistical prerequisites. After the assumptions were satisfied, an Independent Samples t-Test was employed to examine differences in mathematical problem-solving ability between the two groups, while Cohen's d effect size was used to evaluate the magnitude of the effect of the Quizizz-assisted gamification learning model (Noviyanti et al., 2022).

3. Result and Discussion

3.1 Research findings

The purpose of this study is to ascertain how students' mathematical problem-solving abilities in the subject of Systems of Linear Equations with Three Variables (SPLTV) are affected by a gamified learning paradigm utilizing the Quizizz app. At MAN 2 Model Medan, students in Class X-Q served as the experimental group while Class X-R served as the control group for the study.

Table 1. Comparison of Pretest and Posttest Results

Class	N	Pretest	Posttest	Difference
Experimental	32	71,25	86,78	15,53
Control	30	69,87	81,43	11,56

Table 1 shows that following the instruction, students in both classrooms had different average mathematical problem-solving skills. Nonetheless, the experimental class outperformed the control class in terms of average mathematical problem-solving skills. The experimental class's posttest and pretest scores differed by 15.53, but the control group's difference was just 11.56. This suggests that teaching with the Quizizz-assisted gamification paradigm improved students' ability to solve mathematical puzzles.

After obtaining an overview of the mean pretest and posttest scores for the control and experimental classes, the next step was to conduct a statistical test to examine the significance of the difference between the two groups. However, prior to conducting the t-test, prerequisite analysis tests were first carried out, consisting of the normality test and the homogeneity test. Both tests aim to ensure that the obtained data meet the assumptions required for parametric statistical testing, so that the resulting analysis can be statistically justified.

Table 2. Results of the Normality Test

Class	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-test Control	.953	30	.202
Post-test Control	.968	30	.486
Pre-test Experimental	.953	32	.172
Post-test Experimental	.949	32	.133

Table 2 presents the results of the normality test for mathematical problem-solving ability data using the Kolmogorov-Smirnov and Shapiro-Wilk tests. Based on the Shapiro-Wilk test, the significance values were 0.202 for the control class pre-test, 0.486 for the control class post-test, 0.172 for the experimental class pre-test, and 0.133 for the experimental class post-test. Since all significance values were greater than 0.05 (Sig. > 0.05), it can be concluded that the data for all four groups were normally distributed**.**

Table 3. Results of the Homogeneity Test

Test	Levene Statistic	df1	df2	Sig.
Based on Mean	.677	1	60	.414
Based on Median	.619	1	60	.434
Based on Median and with Adjusted df	.619	1	56.987	.435
Based on Trimmed Mean	.698	1	60	.407

The results of the homogeneity test for the mathematical problem-solving ability data are presented in Table 3. The test was carried out using Levene's Test at a significance level of 0.05. Based on the *Based on Mean* result, a Levene statistic value of 0.677 was obtained with df1 = 1 and df2 = 60, yielding a significance value of 0.414. Since this significance value exceeds 0.05, the variance of the data in both groups can be considered homogeneous. As this assumption was met, the data analysis could proceed to hypothesis testing using the t-test.

Table 4. Results of the Independent Samples t-Test

Tabel 4. Hasil Uji-t Sampel Independen (Independent Samples t-Test)

Variabel	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% CI Lower	95% CI Upper
Kemampuan Pemecahan Masalah Matematis	-3,224	60	0,002	-5,348	1,659	-8,666	-2,030

The results in Table 4 show a t value of -3.224 with 60 degrees of freedom (df) and a two-sided significance value of 0.002, which is smaller than 0.05, indicating that H0 is rejected and Ha is accepted. The mean difference of -5.348, with a standard error difference of 1.659, and a 95% confidence interval ranging from -8.666 to -2.030 that does not include zero, further confirm a statistically significant difference between the mathematical problem-solving abilities of students in the control and experimental classes, with the experimental class showing a higher mean than the control class. This finding is consistent with the study by Sagala et al. (2026), which also employed Polya's problem-solving indicators and an independent samples t-test, in which the class receiving a specific instructional treatment demonstrated a significantly higher mean score compared to the control class, suggesting that the instructional treatment applied in the experimental class had a more positive effect on improving students' mathematical problem-solving ability than the conventional approach used in the control class.

Table 5. Percentage of Mathematical Problem-Solving Ability Based on Polya's Indicators

Polya's Indicator	Class control (%)	Class Experimental (%)
Comprehending the Problem	78,5	83,5
Formulating a strategy	78,5	87,0
Executing the Plan	93,0	83,0
Reviewing the outcomes	78,5	90,0

The percentages in Table 5 were obtained by comparing the average scores for each indicator with the maximum score for that indicator on the posttest instrument. Percentages were used because the maximum scores for indicators on the pretest and posttest differed, allowing for a more proportional comparison of the results. Based on Table 2, the “reviewing” indicator achieved the highest score in the experimental class, at 90.0%. Next, the “planning strategies” indicator reached 87.0%, “understanding problems” 83.5%, and “implementing strategies” 83.0%. However, for the “implementing strategies” indicator, the experimental class's percentage (83.0%) was still lower than that of the control class (93.0%). This does not necessarily indicate that the Quizizz assisted gamification learning model was unsuccessful. The “carrying out the plan” stage requires precision in performing arithmetic operations, consistency in following the problem-solving procedure, and the ability to apply the planned strategies. Although students in the experimental class were able to formulate problem-solving strategies well, some students still made procedural errors or lacked precision in the calculation process, thereby affecting their performance on this indicator. These findings are consistent with a systematic review showing that difficulties during the “carrying out the plan” stage are generally caused by procedural errors, misconceptions, and a lack of precision in carrying out the solution steps, rather than by students' failure to understand the problem or their inability to devise strategies.

Figure 1.
Comparison of Polya's Problem-Solving Indicators Between Control and Experimental Classes

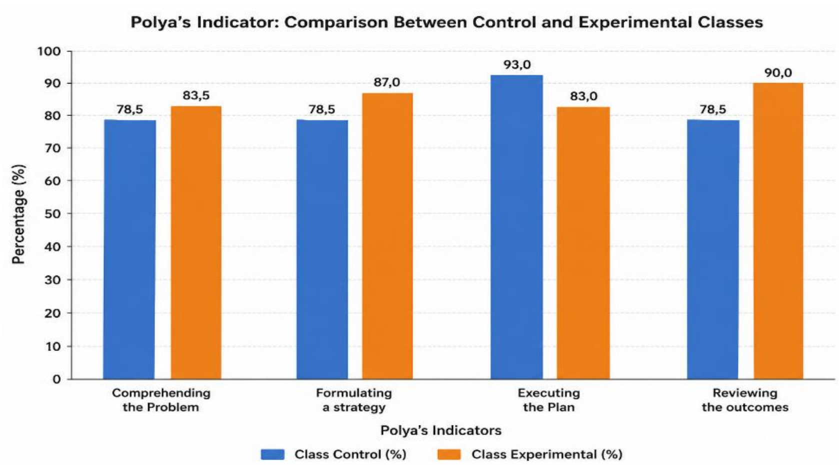

Figure 1 presents a visual comparison of students' achievement across four Polya's problem-solving indicators between the control and experimental classes. Visually, the experimental class (orange bars) outperforms the control class on three of the four indicators, with the most striking gap occurring in the reviewing the outcomes indicator, where the experimental class reached 90.0% compared to only 78.5% in the control class a difference of 11.5 points. A similar pattern is evident in the formulating a strategy indicator, where the experimental class achieved 87.0% versus 78.5% in the control class. Interestingly, the executing the plan indicator shows a reversed pattern: the blue bar (control class) rises higher at 93.0%, while the experimental class stands at 83.0%. This seemingly "inverted" finding is worth examining closely, as it suggests that the experimental class's strength in comprehending problems and formulating strategies has not yet been fully matched by precision during the computational execution stage. This pattern is consistent with the findings of Sagala et al. (2026), who similarly observed that students exposed to an innovative instructional treatment excelled in the comprehension and planning stages, while still requiring reinforcement in the procedural execution of strategies. This confirms that improvements in mathematical problem-solving ability are not uniform across all stages, but rather depend on the specific characteristics of each indicator and how the applied learning model stimulates each stage individually.

Table 6. Hypothesis Test Results and Effect Size

Stastic	Value
$t_{calculate}$	3,22
t_{tabel}	2,000
Sig. (2-tailed)	0,002
Mean Difference	5,348
Cohen's d	0,819
Category	Large

Based on Table 6, the results of the hypothesis test using the Independent Samples t-Test indicate that the calculated t-value of 3.22 exceeds the critical t-value of 2.000 at a 5% significance level ($\alpha = 0.05$) with 60 degrees of freedom (df), supported by a Sig. (2-tailed) value of 0.002 (< 0.05), leading to the rejection of H_0 and acceptance of H_1, with a mean difference of 5.348 and a Cohen's d value of 0.819 falling into the large effect size category, indicating that the Quizizz-assisted gamification learning model exerts an effect that is both statistically significant and practically meaningful on students' mathematical problem-solving skills.

As visualized in Figure 1, this significant improvement was consistently observed across the comprehending the problem, formulating a strategy, and reviewing the outcomes indicators, though not on the executing the plan indicator, where the experimental class scored lower (83.0%) than the control class (93.0%); this finding cannot simply be attributed to a lack of student thoroughness, but is better understood through the lens of cognitive load theory, whereby students' active engagement during the comprehension and strategy-planning stages within gamified learning tends to allocate greater cognitive resources toward higher-order thinking processes, thereby not yet fully strengthening the procedural fluency required during the computational execution stage, consistent with Schoenfeld's (1985) view that mastery of higher-order cognitive strategies does not always correspond linearly to proficiency in basic computational skills, whereas the control class, accustomed to conventional drill-based instruction, was comparatively more procedurally trained despite exhibiting weaker conceptual understanding of the problem context.

3.2 Discussion

The findings indicate that the Quizizz-assisted gamification learning model contributed positively to students' mathematical problem-solving performance in the SPLTV topic. Rather than interpreting the result solely through the statistical difference between the two groups, the findings suggest that the intervention may have influenced how students engaged with mathematical tasks during the learning process. The higher posttest performance of the experimental class and the large effect size indicate that the intervention had meaningful educational relevance. This finding is consistent with Al Wahida et al. (2024), who reported positive effects of Quizizz-assisted mathematics learning on students' problem-solving abilities. Similar findings were reported by Nabila et al. (2025) and Safriana et al. (2025), who emphasized that interactive digital learning environments can support student engagement and mathematical understanding. Siregar (2021) also highlighted the importance of active student participation in developing mathematical problem-solving skills.

The possible contribution of the intervention can be understood through the interaction between Quizizz features and the learning activities. Points and leaderboards provided students with visible performance goals, while rewards encouraged continued participation in learning tasks. Immediate feedback provided information about students' responses, enabling them to recognize errors and reconsider their reasoning. Therefore, the pedagogical mechanism was not simply that gamification increased motivation. Rather, the game elements encouraged students to remain engaged with mathematical problems, receive information about their performance, and repeatedly interact with problem-solving tasks. This interpretation is supported by Sailer and Homner (2020), who found that gamification can positively affect cognitive, motivational, and behavioral learning outcomes, although its effects depend on the design and learning context. Oliveira et al. (2023) similarly emphasized that the effectiveness of gamification is context-dependent and influenced by how game elements are designed and integrated into instruction. Thus, Quizizz may have contributed to learning not merely as a digital quiz platform but as a structured environment that connected challenge, feedback, participation, and reflection. From a constructivist perspective, the intervention may have supported students in actively constructing and refining their mathematical understanding. Students were required to respond to problems, compare their performance, discuss possible solutions, and reconsider their answers after receiving feedback. These activities provided opportunities for students to connect new mathematical information with their existing understanding. In this process, Quizizz functioned as a supporting medium, whereas the construction of mathematical knowledge occurred through students' active engagement with problems and interaction with the learning environment (Vygotsky, 1978). This interpretation is also consistent with the principles of gamification proposed by Deterding et al. (2011) and the findings of Davis et al. (2018), which emphasize that game elements can support engagement when they are meaningfully connected to learning activities.

The analysis of Polya's indicators provides a more specific interpretation of the overall findings. The experimental class obtained 83.5% for understanding the problem, 87.0% for devising a plan, 83.0% for carrying out the plan, and 90.0% for looking back. The strongest performance was therefore observed in the looking-back indicator, followed by devising a plan. The 90.0% achievement in looking back suggests that students were relatively capable of reviewing their solutions and identifying possible errors after completing the mathematical procedures. Immediate feedback may have supported this process by drawing students' attention to the consequences of their responses and encouraging them to reconsider their reasoning. However, feedback is unlikely to be sufficient when students merely observe whether an answer is correct or incorrect. Its pedagogical value becomes greater when it is followed by explanation and reflection. In this respect, the findings support Polya's (1973) view that reviewing a solution involves examining the correctness and appropriateness of the solution process. The 87.0% score for devising a plan also indicates that the experimental students were relatively successful in selecting appropriate strategies for solving SPLTV problems. SPLTV requires students to interpret information, construct mathematical relationships, and determine whether elimination, substitution, or a combination of methods is appropriate. The interactive problem-solving activities may have provided repeated opportunities for students to consider the structure of a problem before proceeding to its solution. This finding is consistent with Afri and Windasari (2021), who emphasized the importance of planning and monitoring strategies in solving SPLTV problems.

An important finding, however, is that the experimental class obtained a lower score on the carrying-out-the-plan indicator than the control class (83.0% compared with 93.0%). This result should not be dismissed as a simple lack of student carefulness. It indicates that improvement in strategic planning does not necessarily lead automatically to accurate procedural execution. In SPLTV, carrying out a plan requires students to maintain equivalent equations across several interconnected algebraic steps. Errors in elimination, substitution, arithmetic operations, or sign manipulation can affect all subsequent calculations. Thus, students may have understood the problem and selected an appropriate strategy but still experienced difficulties in maintaining procedural accuracy. The lower score may also reflect a tension between the characteristics of gamified activities and the cognitive demands of algebraic procedures. Points, rankings, and time-limited activities can encourage active participation and rapid responses. However, solving SPLTV problems requires sustained attention, careful symbolic manipulation, and sufficient time to check each step. Consequently, the competitive and time-oriented aspects of gamification may encourage students to prioritize response speed in some activities, whereas procedural execution requires deliberate and systematic work. This interpretation is consistent with Polya's (1973) distinction between devising a plan and carrying out the plan. It is also consistent with Abdul Wahab et al. (2024), who associated difficulties in the execution stage with procedural and computational errors.

Therefore, the lower performance on this indicator provides an important pedagogical implication rather than evidence that the intervention was ineffective. Quizizz-assisted gamification appears to be more supportive of students' engagement, strategic planning, and reflection than of procedural accuracy by itself. To strengthen the carrying-out-the-plan stage, Quizizz activities should be accompanied by guided practice, explicit error analysis, teacher explanations, and sufficient time for students to write and verify each algebraic step. In the context of SPLTV, post-Quizizz discussions could focus on common errors in elimination and substitution, allowing students to explain not only the final answer but also the reasoning and procedures used to obtain it. Such activities would connect the motivational advantages of gamification with the development of mathematical precision. Overall, the findings provide a more nuanced interpretation of the effectiveness of Quizizz-assisted gamification. The intervention did not improve all aspects of mathematical problem solving in exactly the same way. Its strongest performance was observed in students' ability to review solutions and formulate strategies, whereas the execution of algebraic procedures remained an area requiring further instructional support. This finding is important because it demonstrates that the effectiveness of gamification depends on the cognitive demands of the learning task. Gamification can encourage students to participate, persist, and engage with mathematical problems, but these benefits need to be combined with explicit instructional support when the learning objective requires high procedural accuracy (Sailer & Homner, 2020; Oliveira et al., 2023). Thus, the present study extends previous research by showing that the contribution of Quizizz-assisted gamification should be examined not only through overall achievement but also through the specific stages of mathematical problem solving.

4. Conclusion

Based on the research findings, it can be inferred that the gamification learning model that incorporates the Quizizz application significantly impacts students' abilities to solve mathematical problems related to Systems of Linear Equations with Three Variables (SPLTV). This is corroborated by the results of an Independent Samples t-Test conducted manually, which showed that the computed t-value ($t_{calculated}$) of 3.22 surpassed the critical t-value (t_{table}) of 2.000 (3.22 > 2.000). Additionally, the SPSS analysis yielded a p-value of 0.002 (< 0.05), leading to the rejection of H_0 and the acceptance of H_1. Therefore, the gamification-based learning model facilitated by the Quizizz application does have an effect on students' mathematical problem-solving skills concerning SPLTV content. Especially, for those problems that require problem-solving skills, math teachers should use the gamified learning approach of Quizizz. Future researchers can develop this study in other subjects of mathematics or add variables such as learning motivation, critical thinking ability, or mathematical communication skills to obtain more comprehensive and broader conclusions. However, they do not guarantee results.

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