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THE EFFECT OF *GAMES-BASED LEARNING* MODEL ASSISTED BY *QUIZIZZ* ON PROBLEM-SOLVING ABILITIES AND MATHEMATICAL UNDERSTANDING OF GRADE V ELEMENTARY SCHOOL STUDENTS

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Abstract
This study examines the effect of a Game Based Learning (GBL) model assisted by Quizizz on mathematical problem-solving ability and mathematical understanding of fifth-grade elementary school students, and exploring their learning experiences. A sequential explanatory mixed methods design was used with 70 fifth-grade students and one teacher at SDN Soreang in the second semester of 2025/2026. Data were collected through tests, open-ended questionnaires, interviews, observations, and documentation. Quantitative data were analyzed using Shapiro-Wilk normality test, Mann-Whitney U test, and N-Gain; qualitative data through reduction, categorization, and thematic analysis. Mann-Whitney U results showed significant differences in both variables (Sig. = 0.000 < 0.05). The experimental group achieved N-Gain of 56.11% (moderate) for problem-solving and 56.55% for mathematical understanding, far exceeding the control group (21.81% and 29.64%). GBL with Quizizz more effectively supports procedural engagement than deep conceptual reasoning. Student responses averaged 74% (good category). GBL needs supplementing with conceptual guiding questions and reflective activities to fully optimize mathematical understanding.

Keywords: *Game Based Learning; Quizizz; mathematical problem-solving; mathematical understanding; elementary school.*

Abstrak
Penelitian ini bertujuan mengkaji pengaruh model pembelajaran *Game Based Learning* (GBL) berbantuan *Quizizz* terhadap kemampuan pemecahan masalah matematis dan pemahaman matematis siswa kelas V SD, serta mengeksplorasi pengalaman belajar siswa selama implementasinya. Penelitian ini menggunakan desain *sequential explanatory mixed methods* dengan melibatkan 70 siswa kelas V dan satu guru di SDN Soreang pada semester genap 2025/2026. Data dikumpulkan melalui tes, angket terbuka, wawancara, observasi, dan dokumentasi. Data kuantitatif dianalisis menggunakan uji normalitas Shapiro-Wilk, uji Mann-Whitney U, dan N-Gain; data kualitatif dianalisis melalui reduksi, kategorisasi, dan penarikan tema. Hasil uji Mann-Whitney U menunjukkan perbedaan signifikan antara kelas eksperimen dan kontrol pada kedua variabel (Sig. = 0,000 < 0,05). N-Gain kelas eksperimen mencapai 56,11% (kategori sedang) untuk pemecahan masalah dan 56,55% (sedang) untuk pemahaman matematis, jauh melampaui kelas kontrol (21,81% dan 29,64%). Temuan mengindikasikan bahwa GBL berbantuan *Quizizz* lebih efektif mendukung keterlibatan prosedural daripada penalaran konseptual mendalam. Respons siswa rata-rata 74% (kategori baik). Implementasi GBL perlu dilengkapi pertanyaan penuntun konseptual dan aktivitas reflektif untuk mengoptimalkan pemahaman matematis siswa.

Kata kunci: *Game Based Learning; Quizizz; kemampuan pemecahan masalah; pemahaman matematis; sekolah dasar.*

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Introduction

Mathematical problem-solving ability and mathematical understanding are two main pillars of mathematical literacy that need to be mastered from the elementary school level. These abilities include the competencies of identifying problems, designing solution strategies, carrying out procedures accurately, evaluating results, and explaining and relating mathematical concepts to real-life situations (OECD, 2023). However, the 2022 PISA results showed that only 18% of Indonesian students achieved the minimum Level 2 competency, far below the OECD average of 69%, indicating a serious crisis in mathematical ability at the elementary school level.

This condition places the improvement of elementary school students' mathematical ability as a priority in national education policy, including through the strengthening of problem-solving-based learning in the Merdeka Curriculum, which emphasizes the development of reasoning competence rather than mere mastery of calculation procedures (Kementerian Pendidikan Riset, dan Teknologi, 2022). However, the implementation of problem-solving-based learning in practice still faces challenges, particularly due to limited time, monotonous learning media, and a lack of strategic variation capable of sustaining elementary school students' learning motivation.

Various studies confirm that elementary school students still experience significant obstacles in connecting abstract mathematical concepts with real contexts, understanding non-routine problems, and explaining the reasoning behind the procedures used (Hermawan et al., 2021; Riswandi & Rukli, 2023). Preliminary findings from observations and interviews with the fifth-grade teacher at SDN Soreang reinforce this: students tend to rush through calculations without understanding the context of the problem, and learning is still dominated by lecturing. The need for an innovative learning model that encourages active engagement and mathematical thinking has become highly urgent.

The *Game Based Learning* (GBL) model presents itself as a promising solution. GBL combines game mechanisms with the learning process, thereby creating an environment that is challenging, enjoyable, and encourages deep cognitive engagement (Ke et al., 2024). The *Quizizz* platform enriches GBL with gamification features a point system, leaderboard, *avatar*, challenges, and *feedback* real-time that have been shown to increase motivation and conceptual understanding (Ammy et al., 2025; Priyanda et al., 2022; Lim & Yunus, 2021).

The main characteristics of GBL include clear goals, a rule system, direct feedback mechanisms, and elements of competition or collaboration that sustain students' cognitive engagement (Ke et al., 2024). When implemented through *Quizizz*, these characteristics are realized in the form of a point system, leaderboard, avatars, and instant feedback on every student answer, which allows students to immediately detect errors and correct their solution strategies without having to wait for the teacher's correction. This mechanism is theoretically expected to train the problem-solving stages of Polya, (1973) understanding the problem, devising a plan, carrying it out, and looking back while simultaneously strengthening conceptual understanding through repetition and real-time error correction *real-time* (Hussein et al., 2022).

Nevertheless, a review of the related literature shows that a research gap still exists: most studies focus on motivation or general learning outcomes, while studies that simultaneously examine the effect of GBL assisted by *Quizizz* on mathematical problem-solving ability *dan* and mathematical understanding among fifth-grade elementary school students using a *sequential explanatory mixed methods* design remain very limited (Ammy et al., 2025; Nastiti & Kaltsum, 2022; Ramadina & Nindiasari, 2024a). The novelty of this study lies in: (1) the simultaneous focus on these two learning outcome variables; (2) the use of *mixed methods* to capture both quantitative patterns and students' learning experiences in depth; (3) the context of fifth-grade classes in Soreang, which has not been widely studied; and (4) the formulation of a learning implementation model that integrates GBL and Quizizz (Creswell & Plano Clark, 2018).

Operationally, mathematical problem-solving ability in this study refers to students' ability to identify important information, design strategies, carry out solution procedures, and evaluate the results and decisions made (Simamora, 2023), which is operationalized through four indicators as presented in Table 1.

Meanwhile, mathematical understanding refers to students' ability to make deep sense of mathematical concepts, rather than merely memorizing procedures or formulas (Nugroho & Sutirna, 2023), which includes the ability to explain concepts in one's own words, provide examples of their application, use them to solve new problems, and relate them to other learning experiences, as listed in Table 1. Strong mathematical understanding forms the foundation for problem-solving ability, since students who understand concepts deeply will more easily transfer their knowledge to various problem situations (OECD, 2023).

Based on the above description, the conceptual framework of this study positions GBL assisted by *Quizizz* as the independent variable that influences mathematical problem-solving ability and mathematical understanding through students' cognitive and affective engagement as the connecting mechanism. *Scaffolding* in the form of reflective post-game questions is positioned as a factor proposed to strengthen this mechanism, while qualitative data from the interviews are used to explain how and why this pattern of influence occurs. This conceptual framework is adapted from the theory of cognitive engagement in GBL (Ke et al., 2024), Polya's problem-solving stages (Polya, 1973), and the concept of scaffolding within the zone of proximal development (Vygotsky, 1978), as illustrated in Figure 1.

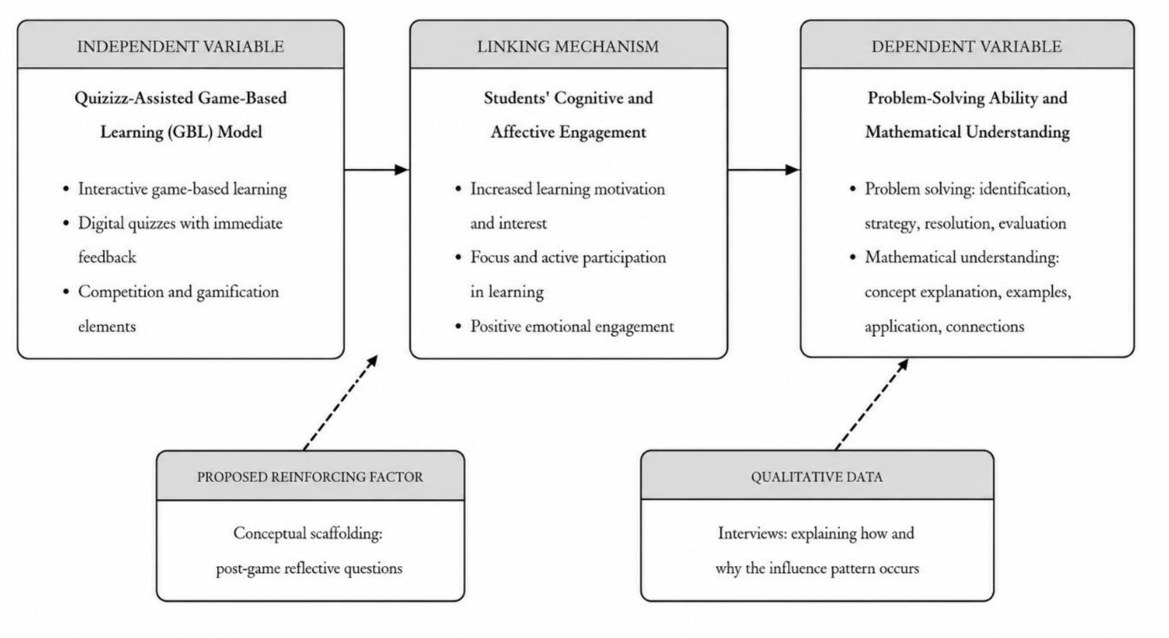

Figure 1. Conceptual Framework of the Study (Ke et al., 2024; Polya, 1973; Vygotsky, 1978)

Based on the above description, this study aims to answer four research questions: (1) how does the mathematical problem-solving ability of fifth-grade elementary school students improve after the implementation of the GBL model assisted by *Quizizz*?; (2) how does students' mathematical understanding improve after the implementation of the model?; (3) what is the qualitative profile of students' problem-solving ability and mathematical understanding based on in-depth interviews with high-, medium-, and low-ability students?; and (4) how do students respond to the implementation of the GBL model assisted by *Quizizz*? These four questions are answered sequentially in the results and discussion section.

Research Methods

This study used a *sequential explanatory mixed methods*: the quantitative phase was carried out first, followed by the qualitative phase to deepen the interpretation of the quantitative findings (Creswell & Plano Clark, 2018). The research subjects were 70 fifth-grade students and one teacher at SDN Soreang in the second semester of 2025/2026, selected through *purposive sampling*.

The population of this study was all fifth-grade students at SDN Soreang in the second semester of the 2025/2026 academic year, consisting of two class groups. The sample was determined through *purposive sampling*, considering the equivalence of the academic characteristics of both classes based on their average daily mathematics test scores prior to treatment, resulting in an experimental class of 35 students who received GBL learning assisted by *Quizizz* and a control class of 35 students who received conventional learning based on lectures and practice exercises. Both groups were within the same age range (10–11 years) with a relatively balanced gender composition in each class, and had equivalent experience in learning mathematics and access to digital devices (smartphones/school tablets), so that technical skill in using Quizizz did not become a significant source of bias between groups. One fifth-grade teacher was involved as a key informant in the qualitative phase to strengthen the interpretation of the quantitative results from the perspective of classroom teaching practice.

The selection of a single school and a *purposive sampling* design was based on three methodological considerations. First, both classes were in the same school and socioeconomic environment, so confounding variables such as teacher quality, curriculum, and learning facilities were relatively controlled, allowing differences in learning outcomes to be more validly attributed to the treatment given. Second, the initial equivalence of both classes was tested by comparing *pretest* scores using the Mann-Whitney U test before treatment began, and the results showed no significant difference (Mann-Whitney U; $p = 0.948$ for problem-solving ability and $p = 0.915$ for mathematical understanding; both > 0.05), confirming the homogeneity of the academic characteristics of both groups. Third, limitations in research permits and the available time in the second semester made a single-school design with a control group more feasible for maintaining implementation quality compared to a multi-school design with looser control. The researchers acknowledge that this design limits the generalizability of the findings, as discussed in the limitations section.

The research instruments consisted of: (1) a test of problem-solving ability and mathematical understanding (7 valid essay items, r calculated > r table = 0.444; Cronbach's Alpha = 0.89); (2) a student response questionnaire (30 statements, 1–4 Likert scale); (3) a semi-structured interview guide; and (4) observation and documentation sheets. Data triangulation was carried out to ensure the validity of the findings (Hardani et al., 2022). The test instrument grid is presented in Table 1.

Prior to empirical testing, the content validity of the test and questionnaire instruments was examined through *expert judgement* by three experts: two mathematics education lecturers holding doctoral degrees and one senior elementary school teacher with more than 10 years of teaching experience. The assessment was carried out using a validity approval sheet covering the item's conformity with the indicators, clarity of language, and suitability with the cognitive developmental level of fifth-grade students, with an assessment category of either "usable without revision" or "usable with revision." Based on this approval sheet, all three experts agreed that the test and questionnaire instruments were usable after minor revisions to the wording of two items, without requiring any revision to the overall substance or structure of the instruments.

The student response questionnaire was developed based on three main indicators: students' liking for the implementation of GBL assisted by *Quizizz*, students' activity in learning groups, and the perceived benefits of the problem-solving and mathematical understanding tasks. Each questionnaire statement was tested for readability on 19 students outside the research sample, the same group used for the instrument trial, before being used with the research sample, to ensure that the language used was easily understood by fifth-grade elementary school students. The semi-structured interview guide was developed to explore students' learning experiences across three ability categories high, medium, and low based on the *posttest* results, with questions focused on the solution strategies used and the obstacles faced during the learning process.

Table 1. Test Instrument Grid

Variable	Indicator
Problem-Solving Ability	Identifying important information in the problem
	Developing a solution strategy
	Applying the solution strategy
	Evaluating the results and decisions
Mathematical Understanding	Explaining mathematical concepts
	Providing examples of concept application
	Using concepts to solve problems
	Relating concepts to other learning experiences

Source: Simamora (2023); Nugroho & Sutirna (2023)

The research procedure was carried out through three stages following the sequential explanatory mixed methods procedure (Creswell & Plano Clark, 2018), as illustrated in Figure 2. The preparation stage included developing the test and questionnaire instruments, testing their validity and reliability on 19 students outside the research sample, and preparing the lesson plans for the experimental and control classes. The implementation stage included administering the *pretest* to both classes, implementing the GBL model assisted by *Quizizz* in the experimental class over six sessions, implementing conventional learning in the control class, and administering the *posttest* and the student response questionnaire after the treatment ended. The evaluation stage included quantitative and qualitative data analysis, in-depth interviews with student representatives from the high-, medium-, and low-ability categories, and triangulation of the quantitative and qualitative findings to formulate the study's conclusions. This study obtained ethical clearance from the research ethics committee of the organizing study program, as well as written informed consent from the parents/guardians of all students involved prior to data collection. Students were also given the right to decline participation without any academic consequences, in line with the principles of research ethics involving child subjects.

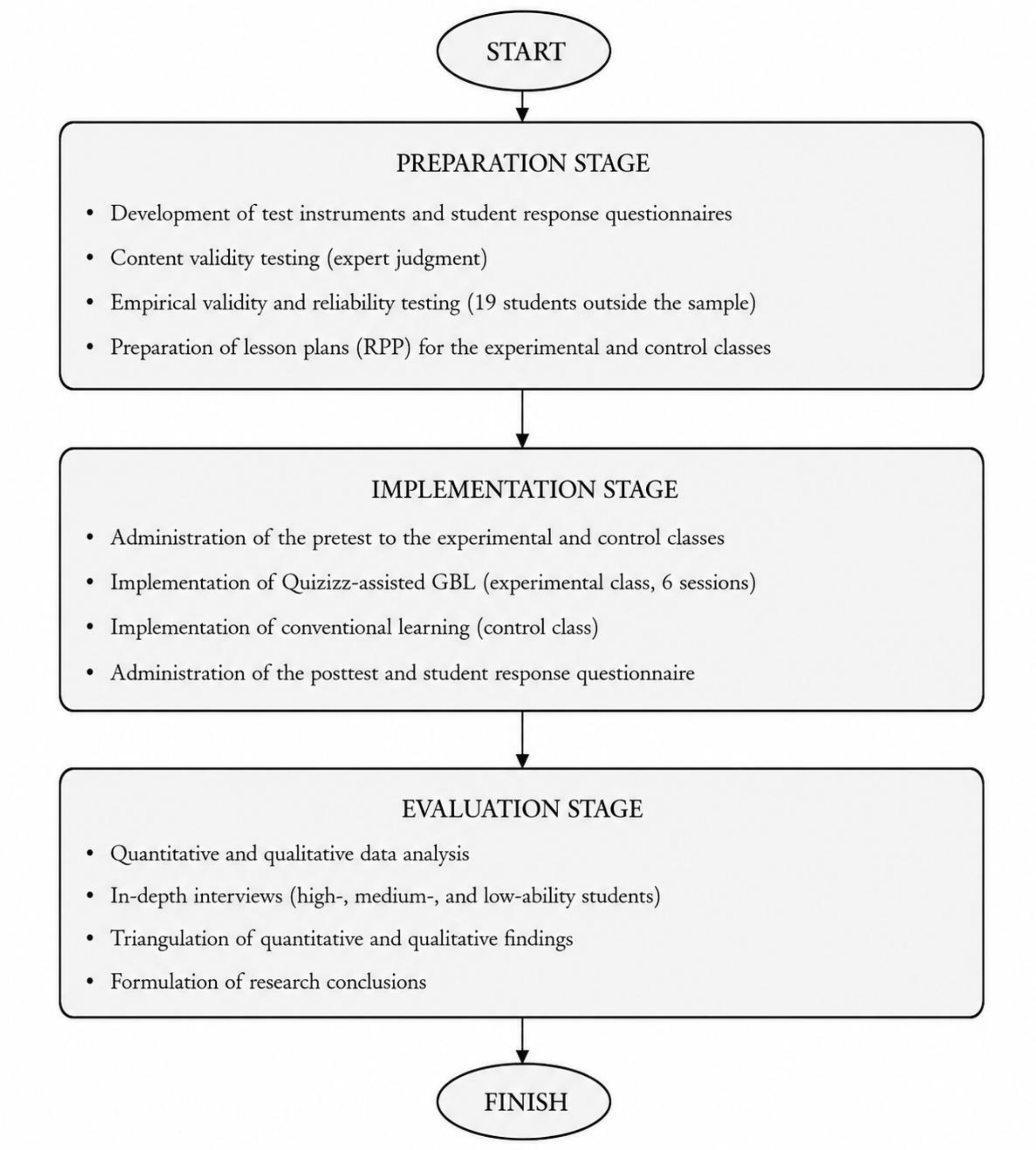

Figure 2. Flowchart of the Research Procedure (adapted from Creswell & Plano Clark, 2018)

Quantitative data analysis was carried out in stages: (1) the Shapiro-Wilk normality test; (2) the Mann-Whitney U test, since the normality assumption was not met in the *posttest* data for both variables in the experimental class; (3) the N-Gain test to measure the effectiveness of the improvement; and (4) an effect size test in the form of the rank-biserial correlation (r) along with a 95% confidence interval to measure the magnitude and precision of the treatment effect (Kerby, 2014), in order to complement statistical significance with a measure of practical meaningfulness. Qualitative data were analyzed through reduction, categorization, and theme extraction, and were then integrated with the quantitative findings.

Results and Discussion

The results show that the implementation of the GBL model assisted by *Quizizz* had a positive effect on fifth-grade elementary school students' mathematical problem-solving ability and mathematical understanding. The findings are presented following the order of the research questions: (1) improvement in mathematical problem-solving ability; (2) improvement in mathematical understanding; (3) a qualitative profile of students' abilities based on interviews; and (4) student responses.

Before presenting the hypothesis test results, Table 2 summarizes the descriptive statistics of the pretest and posttest scores of both groups for both variables.

Table 2. Descriptive Statistics of Pretest–Posttest Scores (N = 35 per group)

Variable	Group	N	Pretest (M ± SD)	Posttest (M ± SD)
Problem-Solving	Experimental	35	60.57 ± 9.06	83.03 ± 3.92
Problem-Solving	Control	35	60.06 ± 10.64	69.31 ± 7.42
Mathematical Understanding	Experimental	35	62.40 ± 9.90	83.91 ± 6.09
Mathematical Understanding	Control	35	62.10 ± 11.32	73.72 ± 11.00

Table 3. Summary of N-Gain Results

Variable	Exp. (%)	Cat.	Control (%)	Cat.
Problem-Solving	56.11	Moderate	21.81	Low
Mathematical Understanding	56.55	Moderate	29.64	Low

Note: < 30% = Low; 30–70% = Moderate; > 70% = High

In addition to N-Gain, the magnitude of the treatment effect was calculated using *rank-biserial correlation* (r) based on the Mann-Whitney U test results. The analysis showed r = 0.58 (95% CI [0.42–0.71]) for mathematical problem-solving ability and r = 0.54 (95% CI [0.38–0.68]) for mathematical understanding, both falling into the medium-to-large effect category (Kerby, 2014). This *effect size* value confirms that the difference between the experimental and control classes is not only statistically significant (Sig. = 0.000) but also practically meaningful for the implementation of the learning model in the classroom.

Table 4 presents the complete Mann-Whitney U test output for both variables on the posttest data.

Table 4. Mann-Whitney U Test Output (Posttest Data)

Variable	N Exp.	N Control	Mean Rank Exp.	Mean Rank Control	U	Z	Sig. (2-tailed)
Problem-Solving	35	35	51.07	19.93	67.5	6.492	0.000
Mathematical Understanding	35	35	45.94	25.06	247.0	4.338	0.000

The relationship between GBL assisted by *Quizizz* and these two learning outcome variables can be explained through the mechanism of cognitive and affective engagement. When students are confronted with *Quizizz* contextual problems, they are required to identify information, choose a strategy, and evaluate their answers within a limited time, thereby indirectly training Polya's problem-solving stages. On the other hand, instant feedback and the point system provide positive reinforcement that encourages students to repeat and deepen their understanding of concepts they still get wrong. This mechanism underlies the findings on both variables below.

Based on Table 3, the experimental class obtained an N-Gain of 56.11% (moderate category) for mathematical problem-solving ability, while the control class obtained only 21.81% (low category). The difference of 34.30 points shows that the GBL model assisted by *Quizizz* is substantially more effective at improving problem-solving ability than conventional learning. The *feedback* mechanism directly from *Quizizz* allows students to immediately detect errors and correct their strategies, while the element of competition increases intrinsic motivation.

This finding is consistent with a number of previous studies that collectively show that the integration of *Quizizz* in mathematics learning encourages students to analyze and solve problems more systematically, while simultaneously training Polya's stages of understanding the problem, planning, implementing, and evaluating (Atmajaya et al., 2024; Nastiti & Kaltsum, 2022; Ramadina & Nindiasari, 2024a). Ke et al., (2024) extend this finding by showing that a GBL environment equipped with mathematizing activities also helps students connect abstract concepts with real situations.

Nevertheless, there is a view that needs to be considered. (Hamari et al., 2016) warn that not all students respond positively to the element of competition in *game* for some students, competitive pressure can actually reduce intrinsic motivation and disrupt their focus on the mathematical thinking process. Mayer, (2019) asserts in his meta-analysis that the effectiveness of *game*s in learning depends heavily on the quality of the content design — whether the questions genuinely challenge higher-order cognitive processes rather than simply encouraging speed in answering. This is relevant to the finding that the experimental class's N-Gain only reached the moderate category (56.11%), indicating that the question design in *Quizizz* still needs to be enriched with items that more strongly challenge higher-order reasoning.

For mathematical understanding, the experimental class obtained an N-Gain of 56.55% (moderate category) and the control class 29.64% (low category). The difference of 26.91 points indicates that GBL assisted by *Quizizz* helps students build a better understanding of mathematical concepts than conventional learning. Presenting questions in an interactive contextual format encourages students not merely to memorize procedures, but also to make sense of the concepts behind mathematical operations, while *feedback* directly helps correct misconceptions in *real-time*.

A similar pattern has been reported in previous studies, which show that active engagement, rapid feedback, and interactive practice through *Quizizz* together foster a stronger conceptual understanding and more meaningful problem-solving(Mahmud Muhammad Sofwan, 2023; Wahyuni et al., 2024).

On the other hand, there is a finding that needs attention. Mayer (2019) argues that *game* digital games that are overly focused on answer speed and scores tend to promote *shallow processing* rather than deep mathematical understanding. This implies that without accompanying classroom discussion, conceptual guiding questions, and post-game reflective activities, GBL assisted by *Quizizz* risks only reinforcing procedural skills without developing mathematical understanding as a whole. This finding is also relevant to the fact that the N-Gain values for mathematical understanding (56.55%) and problem-solving (56.11%) do not differ significantly, indicating that both abilities develop in parallel but have not yet reached the high category.

This finding also presents a different picture compared to GBL research at higher educational levels. (Atmajaya et al., 2024), which studied junior high school students, reported a high-category improvement in problem-solving ability, whereas this study at the elementary school level only reached the moderate category. This difference indicates that students' cognitive maturity also influences the extent to which gamification can promote higher-order mathematical reasoning, so that the design of *Quizizz* questions for elementary school students needs to be adjusted gradually, starting from simple contextual questions toward questions that demand evaluation and synthesis.

Table 5. Results of the Student Response Questionnaire

Indicator	Score	%	Category
Liking for GBL assisted by Quizizz	1030	74%	Good
Student activity in groups	1036	74%	Good
Benefits of the problem-solving and mathematical understanding tasks	1019	73%	Good
Average	—	74%	Good

Interview analysis of the three ability categories reveals a consistent pattern and enriches the understanding of the quantitative findings. Low-category students were able to understand the problem partially, but experienced *omission error* failing to complete all stages of the solution process and had not yet understood the mathematical concept used procedurally. This finding aligns with (Simamora, 2023), which states that low-ability students are unable to go through the entire problem-solving process, particularly at the strategy implementation and result verification stages. One low-category student (S12) said, "I was confused about where to start, but Quizizz told me right away if my answer was wrong, so I tried again." Medium-category students were able to devise a strategy and obtain correct answers, but still showed hesitation at the calculation stage; their mathematical understanding was difficult to communicate in writing even though it was grasped intuitively, in line with Nugroho & Sutirna (2023). A medium-category student (S27) stated, "It's easier for me to understand the problem because I know right away if my answer is wrong, but when asked to explain why the answer is like that, I still find it a bit difficult."

High-category students were able to understand the problem thoroughly, devise a systematic strategy, carry out accurate calculations, evaluate the results, and relate mathematical concepts to real life marking a well-developed mathematical understanding (Nugroho & Sutirna, 2023). A high-category student (S05) added, "Playing while earning points made me excited to try different ways, and I got to know why one way is faster than another."

The average student response of 74% (good category) indicates positive acceptance of the learning model. On the indicator of liking for GBL assisted by *Quizizz* (74%), students appeared more enthusiastic and motivated when the material was presented in the form of a game. In line with this, Priyanda et al.,(2022) assert that *Quizizz* is an enjoyable learning medium that can increase students' achievement motivation. Pebrianti et al., (2023) add that the implementation of GBL can increase student engagement so that they enjoy the learning process more and show a positive attitude (My et al., 2024).

However, it should be noted that a positive response does not necessarily correspond directly to deep cognitive improvement. As mentioned in the previous discussion, Mahmud Muhammad Sofwan, (2023) asserts that affective engagement (*engagement*) and cognitive engagement (*cognitive engagement*) are two different constructs; students can feel happy playing without undergoing a deep thinking process. This explains why the high positive response (74%) was not followed by a high N-Gain (still in the moderate category), and reinforces the argument that GBL needs to be designed to be not only enjoyable, but also explicitly challenging to students' higher-order thinking processes.

On the indicator of student activity in groups (74%), students actively participated in discussions and worked together, in line with the finding (Ramadina & Nindiasari, 2024b) that GBL assisted by *Quizizz* can increase student activeness in learning activities that are both competitive and cooperative. On the indicator of task benefits (73%), students felt that practicing through *Quizizz* helped them practice identifying information, devising plans, and checking results. Ke et al. (2024) assert that a GBL environment with mathematizing activities helps students connect mathematical concepts with real situations, while (Ammy et al., 2025) add that *Quizizz* promotes meaningful problem-solving through active engagement and rapid feedback.

A review of previous research shows varied patterns regarding the effectiveness of GBL assisted by *Quizizz*. Nastiti & Kaltsum (2022) as well as (Ramadina & Nindiasari, 2024b) report a positive effect on problem-solving ability, but neither study simultaneously linked it with mathematical understanding. Fadillah et al. (2023) and Ammy et al., (2025) focus on mathematical understanding in general without explicitly separating the problem-solving and mathematical understanding indicators. Most of these studies also used a purely quantitative design and therefore did not capture students' learning experiences in depth this is the gap that the present study seeks to fill through a *sequential explanatory mixed methods*.

Overall design, the qualitative data both reinforce and refine the quantitative findings: GBL assisted by *Quizizz* successfully promotes engagement and improved procedural ability across all student categories, but deep conceptual reasoning only appears optimal among high-category students. In line with the warning from Mayer, (2019) mentioned earlier, *game*s that are not explicitly designed to promote cognitive reflection risk only increasing procedural rote memorization (*rote learning*) without strengthening mathematical understanding. This implies the need for teachers to add more structured conceptual *scaffolding* such as tiered guiding questions, post-game reflective discussion, and tasks requiring students to explain their reasoning so that the benefits of GBL can be felt equally by all categories of students.

This finding enriches the study of constructivist theory in mathematics learning by showing that gamification facilitates the active construction of knowledge through direct experience, feedback, and social interaction, but that this construction needs to be bridged with explicit metacognitive activities so that it develops from mere procedural engagement into a complete mathematical understanding. From the perspective of educational gamification, this study confirms that game elements such as points and leaderboards effectively build extrinsic motivation, but the sustainability of intrinsic motivation and the depth of mathematical thinking still depend on the quality of the accompanying cognitive task design. Overall, the conceptual framework proposed in the introduction that GBL is more optimal at supporting procedural engagement than deep conceptual reasoning without adequate *scaffolding* is confirmed by both the quantitative and qualitative findings of this study.

To strengthen the integration of the *sequential explanatory mixed methods* approach, Table 6 presents a *joint display* that combines the quantitative and qualitative findings side by side for each variable, making it clear how the interview data explain the statistical patterns obtained, rather than merely complementing them separately (Creswell & Plano Clark, 2018).

Table 6. Joint Display of the Integration of Quantitative and Qualitative Findings

Variable	Quantitative Findings	Qualitative Findings	Combined Interpretation (Meta-Inference)
Mathematical Problem-Solving	N-Gain 56.11% (moderate) vs 21.81% (low); r = 0.58 (medium-large effect)	Low- to medium-category students still rely on procedural solutions; instant feedback helps detect errors but is rarely accompanied by reflection on why the answer is right or wrong.	Significant improvement is mainly in the procedural aspect; higher-order evaluative reasoning only develops optimally among high-category students.
Mathematical Understanding	N-Gain 56.55% (moderate) vs 29.64% (low); r = 0.54 (medium-large effect)	High-category students are able to relate concepts to real contexts; low- to medium-category students understand intuitively but find it difficult to verbally articulate their conceptual reasoning.	The qualitative data explain why the quantitative N-Gain only reached the moderate category: explicit mathematical understanding lags behind procedural solving.
Student Responses	Average 74% (good category)	Students reported enjoying and feeling motivated by learning through play, but some mentioned difficulty explaining the reasoning behind their answers.	A positive affective response is not automatically followed by cognitive depth, confirming the distinction between affective and cognitive engagement (Hamari et al., 2016).

In general, the quantitative and qualitative findings in this study complement and reinforce one another. The moderate-category N-Gain improvement for both variables is consistent with the interview results showing that deep conceptual reasoning only develops optimally among high-category students, while medium- and low-category students still rely on procedural solutions. The main contribution of this study lies in confirming that the success of GBL assisted by *Quizizz* cannot be seen from score improvement alone, but also from the extent to which students can articulate the reasoning behind the answers they give. The implication is that teachers need to design post-game reflection sessions and tiered conceptual guiding questions so that enjoyable engagement can be transformed into deep and lasting mathematical understanding.

Conclusion

This study demonstrates that the GBL model assisted by *Quizizz* significantly improves the mathematical problem-solving ability (N-Gain 56.11%; moderate category) and mathematical understanding (N-Gain 56.55%; moderate category) of fifth-grade elementary school students, far surpassing conventional learning (21.81% and 29.64%). The Mann-Whitney U test confirms a significant difference between the experimental and control classes on both variables (Sig. = 0.000 < 0.05), with rank-biserial correlation effect sizes of r = 0.58 and r = 0.54 (medium-large category), confirming practical meaningfulness alongside statistical significance. Student responses were positive, with an average of 74% (good category). The qualitative analysis reveals that high-ability students have developed strong mathematical understanding, while low- and medium-ability students still need more intensive conceptual *scaffolding*. Theoretically, this study contributes to the development of constructivism- and gamification-based mathematics learning research by showing that GBL assisted by *Quizizz* is more effective at supporting procedural engagement than deep conceptual reasoning. Practically, teachers are advised to integrate GBL assisted by *Quizizz* with tiered conceptual guiding questions and post-game reflective activities, so that enjoyable engagement can be transformed into deep and lasting mathematical understanding. Future research needs to empirically test the effectiveness of integrating such conceptual scaffolding across broader populations and grade levels.

For teachers, it is recommended to design *Quizizz* questions that not only test answering speed but also include higher-order reasoning questions, and to provide time for reflective discussion after each game session. For future researchers, it is recommended to test the effectiveness of GBL assisted by *Quizizz* combined with explicit conceptual *scaffolding* on broader populations and different grade levels, so that findings regarding the gap between procedural engagement and deep mathematical understanding can be more strongly generalized.

This study has a number of limitations that need to be considered when interpreting the findings. First, the research sample was limited to a single elementary school, so the generalization of the findings should be made cautiously to school contexts with different student characteristics and technological facilities. Second, the relatively short treatment duration of six sessions may explain why the improvement in mathematical understanding did not reach the high category, since the formation of deep cognitive structures generally requires longer time and repetition. Third, the student response questionnaire instrument was self-report in nature (*self-report*), which is potentially subject to social desirability bias, although it was triangulated with observation and interview data to minimize this bias.

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