

Game-Based Learning Model Assisted by Board Game Media to Improve Problem-Solving Skills of Elementary School Students

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Abstract

This study aims to determine the effect of the game-based learning (GBL) model assisted by board game media on the mathematical problem-solving abilities of fifth-grade students at SD Al-Azhar 2 Bandar Lampung. This research is motivated by the still low mathematical problem-solving skills of students and the need for a more concrete, interactive, and enjoyable learning model. The method used is quantitative with a quasi-experimental approach through a pretest-posttest control group design. The research sample consisted of 55 students divided into an experimental class (28 students) who received the GBL model treatment assisted by board games, and a control class (27 students) who received a problem-based learning model treatment. Data were collected through an essay test on problem-solving skills that had been tested for validity, reliability, difficulty level, and discrimination power, and then analyzed using the Shapiro-Wilk normality test, the test Levene's homogeneity test and hypothesis testing with an Independent Sample T-Test were conducted. The analysis results showed that the data from both groups were normally distributed and homogeneous, while the hypothesis test obtained a t-value of -6.541 with a significance of <0.001 (<0.05), so H_0 was rejected and H_1 accepted. The average posttest score of the experimental class was 78.12, higher than the control class which scored 77.66. Therefore, it can be concluded that the GBL learning model assisted by board game media significantly affects the mathematical problem-solving skills of fifth-grade elementary school students, making it a viable alternative as an innovative mathematics learning model at the elementary level.

Keywords: *Game Based Learning, Board Game, Mathematical Problem-Solving Skills, Elementary School*

INTRODUCTION

Mathematical problem-solving is a central goal of elementary mathematics education because it requires students to interpret information, select appropriate strategies, perform mathematical operations, and evaluate the reasonableness of their answers. In fraction learning, these processes connect conceptual understanding with the application of mathematics to contextual problems. However, students' performance across problem-solving stages remains uneven. Sagita et al. (2023), in a study of elementary students solving fraction word problems, identified stronger performance in understanding problems and planning solutions than in executing plans and checking answers. This finding highlights a pedagogical problem: understanding a question does not necessarily enable students to complete and evaluate its solution. Mathematics instruction therefore needs to provide sustained opportunities to practise the entire problem-solving process.

The cognitive demands of these tasks extend beyond recalling fraction procedures. Ji and Guo (2023) identified an association between working memory and mathematical problem-solving, suggesting that maintaining relevant information is part of the challenge. At the instructional level, Yeza et al. (2025) reviewed elementary mathematics research on metacognitive strategies and highlighted planning, monitoring, evaluation, and teacher guidance. Together, these perspectives support tasks that make reasoning and solution checking visible, while avoiding the assumption that a correct final answer necessarily reflects a complete problem-solving process.

This problem is evident at SD Al-Azhar 2 Bandar Lampung. Preliminary interviews with fifth-grade teachers indicated that mathematics instruction relied predominantly on explanations, exercises, and classroom discussions, with textbooks and worksheets serving as the principal learning resources. A preliminary written assessment involving 54 students showed that 16.67% demonstrated very low problem-solving ability and 37.04% demonstrated low ability, whereas only 20.37% reached the high category. Although teachers had introduced animated PowerPoint presentations, group discussions, question-and-answer activities, and contextual exercises, substantial difficulties persisted. These findings establish the need for an instructional approach that gives students more structured opportunities to interpret mathematical challenges, discuss alternative strategies, execute solutions, and examine their answers through concrete and interactive learning activities.

Game-based learning (GBL) supported by physical board games offers a promising approach to this need by organising mathematical tasks within rule-governed play. Its pedagogical value depends on how game activities engage students in mathematical reasoning. Navarrete-Ulloa and Munoz-Rubke (2022) demonstrated that a board game incorporating spatial relationships corresponding to rational-number concepts improved fifth-grade students' fraction knowledge compared with an active control condition. Meanwhile, Nautiyal et al. (2024) developed and implemented a classroom board-game framework that supported student-led mathematical problem-solving and elicited positive feedback regarding engagement and peer interaction. These studies provide a rationale for integrating mathematical content, collaborative activity, and instructional guidance within gameplay. For the present study, this integration is directed towards practising the four stages of Polya's problem-solving framework.

The distinction between digital and physical games is important when interpreting the evidence. Dan et al. (2024) mapped digital-game research specifically in primary mathematics, whereas Russo et al. (2024) synthesised non-digital classroom games and found generally positive outcomes across varied mathematical proficiencies and dispositions. Their reviews support investigating both formats but do not establish that results from one medium automatically transfer to the other. Lin and Cheng (2022), for example, reported improved achievement, motivation, and attitudes with a technology-enhanced board game for prime factorisation. Its hybrid medium and different mathematical topic make it a useful design comparison rather than direct evidence about physical fraction games.

Broader syntheses provide support for investigating GBL while preserving distinctions among outcomes. Karakoç et al. (2022) synthesised achievement studies across disciplines, and Hui and Mahmud (2023) reviewed cognitive and affective outcomes in mathematics. Barz et al. (2024) found benefits for cognitive and affective-motivational outcomes in school-based digital games but no significant pooled benefit for metacognitive outcomes. Anggoro et al. (2025) focused more specifically on higher-order thinking in mathematics. These bodies of evidence provide complementary reasons to examine learning through games; they do not demonstrate that motivation, higher-order thinking, and performance across Polya's stages improve together in every intervention.

Nevertheless, existing evidence does not establish that game-based instruction consistently produces better mathematical outcomes than alternative approaches. Putri and Fajri (2023) reported improved elementary students' problem-solving performance following a board-game intervention, but their development study used a single-group pretest–posttest comparison. Rangkuti et al. (2024) found a significant effect of GBL on mathematical problem-solving through a quasi-experimental comparison, although their participants were senior high school students. Furthermore, Bhatia et al. (2023), in a preregistered randomised study involving fifth graders, found that students receiving classroom instruction outperformed the digital-game group in overall fraction knowledge, despite a benefit for decimal learning. These differences in design, educational level, medium, and outcome indicate that promising findings require further testing against an instructional comparator appropriate to the intended learning objective.

Transfer also requires explicit investigation. Nuraydin et al. (2022) found gains on trained fraction number-line tasks without transfer to broader fraction understanding or arithmetic. Demedts et al. (2024) examined explanatory adaptive feedback in a fraction game and reported differentiated cognitive and non-cognitive outcomes. In a subsequent item-level study, Demedts et al. (2025) found improving correctness during gameplay without a corresponding reduction in the targeted misconception errors. These findings support including explanations, independent tasks, and reflection when fraction games are intended to develop problem-solving rather than only performance within the game.

An active PBL comparator is therefore relevant. Salsabila and Asih (2024) synthesised studies of PBL and mathematical problem-solving and reported favourable results relative to conventional instruction. This provides a rationale for comparing GBL with another approach that already offers opportunities for investigation and reasoning. The present comparison asks whether the complete board-game-assisted instructional package offers additional value under the study conditions, rather than whether games outperform an absence of active learning.

Taken together, these studies leave insufficiently resolved whether physical board-game-assisted GBL, explicitly structured around Polya's stages, supports fifth-grade students' mathematical problem-solving more effectively than problem-based learning (PBL). The present study addresses this question through a nonequivalent pretest–posttest control-group design at SD Al-Azhar 2 Bandar Lampung. Its distinctive contribution lies in

combining the “Fraction Adventure” board game, fraction problem-solving challenges, and guided reflection with an active PBL comparison covering the same mathematical content. The study therefore examines the comparative value of two approaches that both involve students in solving problems. It aims to contribute empirical evidence on the relationship between structured gameplay and mathematical problem-solving, while providing teachers with a context-specific basis for considering board-game-assisted GBL in elementary fraction instruction.

METHODS

Research Design and Context

This study uses a quantitative approach with an experimental research type. The method used is a Quasi-Experimental Design in the form of a nonequivalent control group design. This design involves two groups: an experimental group that receives the Game Based Learning (GBL) model assisted by board game media, and a control group that receives the Problem Based Learning (PBL) model. Both groups are given a pretest before the treatment and a posttest after the treatment, so the difference in results ($O_2 - O_4$) is used to see the effect of the treatment given. This research was carried out at SD Al-Azhar 2 Bandar Lampung in the odd semester of the 2026/2027 academic year.

Population and Sample

The population in this study includes all fifth-grade students at SD Al-Azhar 2 Bandar Lampung. The research sample consisted of 55 students, consisting of 28 fifth-grade students from Sayyidah Khadijah class who were designated as the experimental group with the treatment of the Game Based Learning model assisted by board game media, and 27 fifth-grade students of Sayyidah Aisyah class were designated as a control group with the treatment of the Problem Based Learning model.

The sampling technique was saturated sampling (total sampling): all 55 students in the defined fifth-grade population were included without individual random sampling. Measuring the entire finite population is one recognised basis for explaining sample size (Lakens, 2022). Here, this justification applies to the two classes at the study site; it does not establish representativeness of elementary students elsewhere or eliminate uncertainty in comparisons between intact classes.

Research Procedure

The research was carried out in several stages. In the initial stage, the researcher conducted a pre-study through interviews with the homeroom teachers of classes VA and VB and distributed written essay tests to identify the students' initial mathematical problem-solving abilities. Next, the test instruments that had been prepared were trialed on students outside the research sample, namely 23 fifth-grade students of SD Al-Azhar 1 Bandar Lampung, in order to obtain data on validity, reliability, difficulty level, and the discriminatory power of the test items.

Once the instruments were deemed suitable for use, the research continued with the administration of a pretest to both groups to measure the initial mathematical problem-solving abilities of the students. The experimental group was then given treatment in the form of Game Based Learning using a board game called 'Fraction Adventure' for four sessions (2×35 minutes each session) covering fractions, including addition-subtraction operations, multiplication-division by whole numbers, equivalent fractions, and mixed fractions. In each session, students were divided into small groups to play a board game containing challenge cards with problem-solving questions, through the stages of game orientation, concept exploration, structured play, reflection-discussion, and reinforcement-summary. The control group during the same period received the Problem Based Learning model with the same material, going through the stages of student problem orientation, learning organization, group investigation, presentation of work results, and analysis and evaluation of the problem-solving process.

After the treatment was carried out on both groups, the researcher gave a posttest using an instrument equivalent to the pretest to measure the students' final math problem-solving abilities. The posttest data obtained were then analyzed through prerequisite tests and hypothesis testing to answer the research questions.

Research Instrument Construct.

The instrument was an essay test of mathematical problem-solving ability, designed around Phase C Mathematics Learning Outcomes (CP) and the grade V Learning Objective Flow (ATP) for fractions. Its construct followed Polya's (1957) four stages: understanding the problem, devising a plan, carrying out the plan, and looking back. These stages are also used in contemporary analysis of elementary students' mathematical problem-solving (Sagita et al., 2023). Cognitive demands progressed from understanding (C2) and applying (C3) to analysing (C4) and evaluating (C5), following the revised taxonomy of Anderson and Krathwohl (2001). Two equivalent sets were prepared, Package A for the pretest and Package B for the posttest, each initially containing 10 essay questions with a 1–4 scoring rubric for each item.

Validity Test.

The validity test was carried out using the Pearson product-moment correlation technique on the results of the trial instrument with 23 fifth-grade students at SD Al-Azhar 1 Bandar Lampung, with the criterion that an item is considered valid if the calculated $r >$ the table r at a 5% significance level (table $r = 0.413$). The results of the pretest instrument validity test showed 8 valid items and 2 items (numbers 6 and 9) were declared invalid, while the posttest instrument validity test showed 8 valid items and 2 items (numbers 4 and 9) were declared invalid. Items that were not valid were not used in collecting research data, so each final instrument consists of 8 items that have met the validity criteria.

Reliability Test.

The reliability test was conducted on the items that had been declared valid, using Cronbach's Alpha formula with the help of SPSS version 27. An instrument is considered

reliable if the reliability coefficient value is greater than 0.60. The calculation results showed a Cronbach's Alpha value of 0.869 for the pretest instrument and 0.847 for the posttest instrument, so both instruments are considered to have a high level of reliability and are suitable to be used as data collection tools.

These coefficients describe internal consistency of the scores obtained with the retained items. They should be interpreted in relation to the measurement structure and characteristics of the items, rather than treated as proof of validity (Doval et al., 2023). Orçan (2023) also shows that the performance of alpha and omega depends on sample size, item characteristics, and model conditions. Accordingly, the present alpha estimates do not establish equivalence between the two test forms or agreement among essay scorers; those properties require separate evidence.

Difficulty Level and Discriminatory Power.

The difficulty level test was conducted by comparing the average score of students to the maximum score of each item. The analysis results showed that most items fall into the medium category, with a few items in the easy category, and no items were found to be in the difficult category. The discriminatory power test was calculated based on the Corrected Item-Total Correlation value through SPSS, with results ranging from poor to very good. Items with adequate discriminative power were retained as the final research instruments.

Data Collection

Research data were collected using written test techniques in the form of essays given at the pretest and posttest stages, with the aim of measuring students' cognitive abilities in solving math problems before and after the treatment. In addition, during the pre-research stage, interview guidelines were used with fifth-grade teachers to obtain initial data on the conditions of math learning in the field, as well as observation sheets to observe students' activeness and involvement during the learning process.

Data Analysis Techniques

Research data were analysed quantitatively using IBM SPSS Statistics version 27. Shapiro-Wilk tests were conducted on the pretest and posttest score distributions at $\alpha = .05$, and Levene's test was used to assess equality of variances. The reported hypothesis test was an independent-samples t-test. For the specified comparison, a two-sided p value below .05 was interpreted as evidence against the null hypothesis of equal population means; a p value above .05 would indicate insufficient evidence to reject that hypothesis. The diagnostic results and the correspondence of the reported inferential output to the two-group comparison are examined in the Findings and Discussion section.

FINDING AND DISCUSSION

Mathematical Problem-Solving Performance under GBL and PBL

The final assessment showed that students receiving board-game-assisted game-based learning (GBL) obtained a mean posttest score of 78.12, whereas students receiving problem-based learning (PBL) obtained a mean of 77.66. The GBL group comprised 28

students, and the PBL group comprised 27 students. Accordingly, the GBL group's mean was descriptively higher by 0.46 points. This difference favours the GBL group but does not, by itself, establish a substantial or educationally meaningful advantage. Assessing its magnitude requires standard deviations, confidence intervals, and an effect-size estimate. Furthermore, posttest means alone do not demonstrate improvement, which must be evaluated using students' performance before and after instruction.

Score distributions were examined using the Shapiro–Wilk test for each combination of instructional group and assessment occasion. As shown in Table 1, all *p* values exceeded .05. These results indicate insufficient evidence to reject the normality assumption for the four score distributions. This interpretation is more appropriate than treating normality as conclusively established. Distributional testing also cannot establish baseline equivalence because normality and equality of initial group means concern different statistical properties.

Table 1. Shapiro–Wilk Test Results

Assessment occasion	Group	W	p
Pretest	Board-game-assisted GBL	.944	.143
Pretest	PBL	.942	.137
Posttest	Board-game-assisted GBL	.942	.120
Posttest	PBL	.935	.094

Note. All *p* values exceeded .05, indicating insufficient evidence to reject normality based on these tests.

The reported variance assessment produced a Levene statistic of 1.819 with *p* = .148, as presented in Table 2. This result provides insufficient evidence to reject equal variances among the groups included in that analysis. However, the reported degrees of freedom, *df*₁ = 3 and *df*₂ = 106, require clarification. They do not correspond to a variance comparison involving two independent groups of 28 and 27 students. Consequently, Table 2 cannot yet justify selecting the *equal variances assumed* result for the GBL–PBL posttest comparison.

Table 2. Reported Levene Test Results

Variable	Levene statistic	<i>df</i> ₁	<i>df</i> ₂	p
Mathematical problem-solving ability	1.819	3	106	.148

The reported hypothesis test yielded *t* = −6.541, *df* = 52, and *p* < .001, as shown in Table 3. If this output corresponds to the comparison between the two instructional groups on the specified outcome, its *p* value indicates rejection of the null hypothesis of equal population means for that contrast. Nevertheless, the correspondence between the test output, posttest means, and number of analysed students must be established before interpreting the result as evidence of an instructional effect. The negative sign of the *t* statistic does not indicate a negative effect of GBL; its direction depends on the order in which group means were subtracted.

Table 3. Reported t-test Results

Variable	t	df	Two-sided p
Mathematical problem-solving ability	-6.541	52	< .001

Distinguishing descriptive differences, statistical significance, and educational relevance is essential to answering the research question. The 0.46-point mean difference is insufficient to establish a substantial practical advantage of GBL over PBL. Conversely, a limited numerical difference cannot establish equivalence without an appropriate equivalence analysis. The directly supported finding is therefore that the GBL group obtained a higher posttest mean. Conclusions about the statistical significance and magnitude of its advantage require consistent analytical output and more complete statistical reporting.

This finding should be situated within research demonstrating that the benefits of game-based instruction depend on intervention characteristics and the outcomes assessed. Navarrete-Ulloa and Munoz-Rubke (2022) found that a board game linking spatial relationships with rational-number concepts supported fifth-grade students' fraction learning compared with a control game. However, Bhatia et al. (2023), in a preregistered randomised study involving fifth graders, found that classroom instruction produced better overall fraction knowledge than a digital-game intervention, although the game benefited decimal learning. These studies demonstrate that introducing a game does not guarantee superior performance across all mathematical outcomes. Differences may relate to the alignment of game mechanics, instructional support, comparison conditions, and the relationship between gameplay and the assessed construct.

Using PBL as the comparison condition gives the present study a specific interpretive context. Students in the comparison group also received instruction involving problem-solving and collaborative investigation. The comparison therefore examines the additional value of board-game-assisted GBL relative to another active instructional approach. This differs from Vita-Barrull et al. (2024), who compared a board-game programme with regular instruction and identified greater improvements in selected academic skills and working-memory updating. Their findings support the potential of board games in primary education but do not directly establish superiority over PBL in fraction problem-solving. In the present study, the proximity of the posttest means may reflect relevant learning opportunities in both conditions. This remains a possible explanation rather than an established mechanism because detailed process findings and change-score data have not been reported.

Evidence from younger children also needs a clear developmental boundary. Balladares et al. (2024) reviewed board-game studies in prekindergarten and kindergarten, while Alotaibi (2024) synthesised GBL in early childhood education. Thai et al. (2022) evaluated personalised digital mathematics games through a cluster randomised trial with transitional-kindergarten and kindergarten classrooms. These studies show that playful mathematical instruction can be examined systematically across ages. However, their learners, number concepts, and game formats differ from fifth-grade fraction word problems; their results cannot substitute for direct evidence on the outcome assessed here.

Integrating Polya's Stages into Fraction Gameplay and Its Pedagogical Meaning

The intervention's principal feature was the use of "Fraction Adventure" to organise fraction problem-solving practice through group gameplay. Instruction comprised four 70-minute sessions involving orientation, concept exploration, structured gameplay, reflection and discussion, and reinforcement. Within this design, mathematical challenges were connected to four problem-solving processes: understanding the problem, planning a solution, carrying out the plan, and checking the result. This integration provides a pedagogical basis for explaining how a game can function as an environment for guided mathematical reasoning.

Conceptually, challenge cards can present situations requiring students to identify relevant information and select a solution strategy. Group discussion can create opportunities to compare strategies, while reflection can encourage examination of the relationship between solution procedures and final answers. These potential mechanisms must, however, be distinguished from empirical findings. Overall test scores do not identify which of Polya's stages developed most, and detailed observational findings have not been presented. Accordingly, the study cannot yet claim that increased motivation, improved interaction, or stronger answer-checking skills were demonstrated mechanisms explaining the performance difference.

This distinction is relevant to Sagita et al. (2023), who found uneven performance across Polya's stages among elementary students solving fraction word problems. Understanding problems and planning solutions were stronger than executing plans and checking answers. Their findings suggest that problem-solving instruction must sustain attention throughout the solution process. For "Fraction Adventure," the implication is that success during gameplay should be connected to the quality of students' reasoning and evaluation of solutions. If activities reward only correct answers or speed, students may practise fraction operations without receiving sufficient opportunities to evaluate the accuracy of their solutions.

The importance of instructional organisation also aligns with Nautiyal et al. (2024), who developed and implemented a board-game design framework for mathematics problem-solving sessions. Their study emphasised the relationship between game design and classroom implementation and reported positive student experiences concerning engagement and interaction. In the present intervention, orientation, discussion, and reflection provide a foundation for connecting gameplay with instructional objectives. Nevertheless, enjoyable participation should not substitute for evidence of conceptual understanding. Individual assessment remains necessary to determine whether skills displayed during collaborative gameplay can also be applied independently.

Recent contextual reviews also place teacher preparation and instructional alignment at the centre of implementation. Yulianto et al. (2025) identified prior knowledge, game design, intervention duration, and teacher preparedness as relevant conditions in digital mathematics learning. Putra et al. (2025) discussed the need for teacher training, appropriate

media, and curricular integration, while Oktaviani et al. (2026) mapped GBL implementation in mathematics across educational levels. For “Fraction Adventure,” these findings suggest checking that each turn requires reasoning aligned with the fraction objective and that discussion time allows students to explain their decisions. This is an implication for implementation, not a measured mechanism in the present study.

Putri and Fajri (2023) offer a closer comparison in the elementary-school context. Their development study reported improved problem-solving performance following a board-game intervention using pretest and posttest measurements. The present study extends that question by including a PBL comparison group, directing attention towards differences between two instructional approaches. A comparison condition provides a broader basis for interpretation than observing change within a single group. However, a quasi-experimental design involving two intact classes does not eliminate differences in initial ability, classroom characteristics, or instructional implementation. Its contribution therefore concerns more specific comparative evidence, while causal certainty remains limited.

Rangkuti et al. (2024) also reported an effect of GBL on mathematical problem-solving through a quasi-experimental study, but their participants were eleventh-grade students. The present study examines a different context: fifth-grade fraction problem-solving using a physical game and an active PBL comparison. Differences in educational level, mathematical content, and comparison conditions make this study relevant as an additional contextual investigation. Nevertheless, findings pointing in a similar direction across studies do not establish consistent GBL effectiveness across all educational levels. Such a conclusion requires evidence accounting for variation in research designs and participant characteristics.

Contributions and Implications

The study’s novelty lies in the combination of its target ability, instructional design, and comparison condition. It connects practice across Polya’s four stages with fraction challenges in the physical board game “Fraction Adventure” and compares this approach with PBL among fifth-grade students. This claim is more proportionate than describing the study as the first use of board games in elementary education. Previous research has already investigated board games for fraction learning and primary-school academic skills. The present study addresses a more specific question: the additional value of gameplay organised around problem-solving processes when the comparison condition also involves active instruction.

The theoretical contribution concerns the operational connection between problem-solving stages and the organisation of gameplay. The intervention illustrates how cognitive objectives can be incorporated into a sequence of orientation, challenges, discussion, and reflection. Its empirical contribution is a comparison of two instructional approaches within fifth-grade fraction learning at SD Al-Azhar 2 Bandar Lampung. However, aggregate outcome data do not identify the contribution of individual intervention components. The

effects of GBL, board-game use, collaboration, and reflection cannot be separated. Explanations should therefore concern the instructional package as a whole.

Practically, the intervention design provides direction for teachers developing games that preserve meaningful mathematical demands. Challenge cards should require students to identify information, explain their strategy choices, demonstrate calculations, and evaluate the reasonableness of answers. Group discussion can be followed by individual tasks to assess each student's understanding. Reflection should also provide opportunities to examine errors and alternative solutions. These implications are recommendations derived from the intervention's structure and relevant literature; they do not establish that each process improved in the present study.

Game selection should also reflect the classroom context. Wardani and Himmah (2026) reviewed traditional games in elementary mathematics and emphasised cultural resources, concrete activity, and systematic teacher involvement. Their review concerns traditional and ethnomathematical games rather than the specific board game used here, but it reinforces the need to connect rules and representations with mathematical meaning. Yang and Zhao (2026), in a qualitative first-grade classroom study, likewise identified issues in game design, teacher guidance, and evaluation. These implementation findings support clear rules, an appropriate level of challenge, and feedback on reasoning, while their different settings limit direct comparison with this fifth-grade intervention.

At the school level, physical board games can be considered for limited implementation accompanied by learning-outcome evaluation. Their use requires clear rules, tasks aligned with instructional objectives, scoring rubrics, and arrangements supporting participation within groups. Decisions about wider implementation should consider individual achievement, teacher preparation time, and implementation consistency. This study did not measure costs, workload, or implementation sustainability; therefore, economic benefits and readiness for large-scale adoption cannot yet be established.

Interpretation is limited by the inclusion of one classroom per condition, the absence of individual randomisation, the four-session intervention, and the lack of a retention assessment. Pretest means and standard deviations are also needed to evaluate baseline differences and changes in performance. Furthermore, equivalence between the two test forms requires adequate supporting evidence, particularly because different items were removed from each form. The Levene-test configuration and t-test output must be clarified before definitive inferential conclusions are drawn. Further research could include multiple classrooms per condition, account for initial ability, and report performance across individual Polya stages to examine the proposed instructional mechanisms more directly.

The directly supported result is that board-game-assisted GBL produced a posttest mean 0.46 points higher than PBL. The study provides a specific context for investigating the integration of physical gameplay, Polya's stages, and fraction instruction. However, establishing a statistically significant and educationally meaningful advantage requires

verification of the analysis and reporting of an effect-size estimate. These boundaries locate the study's contribution in comparative evidence that can be examined and substantiated.

CONCLUSION

This study found that students receiving board-game-assisted game-based learning (GBL) achieved descriptively higher final mathematical problem-solving performance than those receiving problem-based learning (PBL). However, a statistically significant and educationally meaningful advantage cannot be established until the analytical output is verified and the magnitude of the difference is evaluated. The study therefore provides preliminary comparative evidence that remains insufficient to establish the superiority of board-game-assisted GBL over PBL.

The study contributes a contextual investigation of fraction instruction integrating Polya's problem-solving stages into the physical board game "Fraction Adventure," with PBL as an active comparison condition. This design clarifies how problem-solving objectives can inform the organisation of gameplay, although the mechanisms underlying the performance difference have not been empirically identified. Practically, board games may be considered as tools for problem-solving practice accompanied by discussion, reflection, and individual assessment. Their use should prioritise mathematical reasoning and solution checking.

Interpretation is limited by the single-school setting, one classroom per condition, absence of individual randomisation, brief intervention, and lack of retention assessment. Statistical consistency also requires verification before definitive inferential conclusions can be drawn. Future studies should include multiple classrooms per condition, account for baseline ability, and report effect sizes and performance across individual problem-solving stages. Classroom implementation should incorporate ongoing evaluation to determine whether participation during gameplay is accompanied by independent mathematical understanding.

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