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Congklak-Assisted PBL for Elementary School Mathematical Problem-Solving Skills

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Abstract: Mastering mathematical problem-solving is a crucial 21st-century skill, yet many elementary students continue to struggle with abstract concepts. Conventional teaching methods often fall short of bridging this gap, underscoring an urgent need for innovative, concrete instructional approaches. Therefore, this study seeks to assess the effectiveness of the Problem-Based Learning (PBL) model, combined with the congklak game media, in improving elementary school students' mathematical problem-solving abilities, particularly in the KPK and FPB topics. A quasi-experimental method employing a Nonequivalent Control Group Design was utilized. The study included 52 students in Purwakarta, distributed equally into an experimental class receiving PBL with congklak and a control class applying Discovery Learning. Data were gathered through descriptive tests based on Polya's problem-solving indicators and then analyzed using independent-samples t-tests and N-Gain calculations. The results demonstrate a notable improvement in the experimental group, which attained a mean post-test score of 92.15, compared with the control group's 85.81 ($p < 0.001$). Furthermore, the N-Gain analysis showed that the experimental class outperformed the control class across all problem-solving indicators, with the most substantial differences seen in planning the solution (0.92 vs. 0.72) and implementing the plan (0.81 vs. 0.66). In conclusion, applying the PBL model alongside concrete congklak media significantly enhances students' mathematical problem-solving skills by fostering an active, tangible learning environment. Consequently, educators are encouraged to integrate traditional game-based manipulatives into their pedagogy. This strategy not only deepens mathematical comprehension but also helps preserve local cultural heritage among young learners.

Keywords: problem-solving skill, congklak media, problem-based learning, elementary school.

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INTRODUCTION

Primary education plays a central role in shaping children's reasoning abilities. In the curriculum, mathematics holds a strategic position because it trains systematic and logical reasoning when facing problems. Entering the 21st century, the educational paradigm has shifted; mastery of theory alone is no longer sufficient, as students are required to think critically and independently to unravel their learning problems (Riska, Ratnasari, Trimadani, Halimatussakdiah, & Nathalia Husna, 2022). The ability to think mathematically includes various aspects, ranging from logical and creative to analytical thinking. For this reason, the importance of innovative learning models in fostering the creativity of elementary school students is highlighted (Khawani & Rahmadana, 2023).

In reality, solving mathematical problems requires a series of cognitive stages. Students are not advised to immediately guess the final result without a clear process; rather, starting from identifying the problem, designing a strategy, executing the plan, and validating the final answer requires a series of thinking processes (Al-Jehada B. Gulam & Joel C. Arenas, 2024; Devi et al., 2025; Wahab A et al., 2024). The interconnection between these stages is very close, with success in one step determining the next. Such skills transcend mere rote memorization methods and enter the domain of Higher-Order Thinking Skills (HOTS). This includes proficiency in analyzing constraints, testing alternative solutions, making logic-based decisions, and formulating strategies independently (Sulistifa et al., 2025). In other words, solving math problems is an intellectual activity that requires decision-making maturity from every student.

Field reality indicates weak conditions. Many elementary school students still struggle with word problems, are unable to formulate appropriate solution strategies, and frequently make calculation errors (Ling, 2023). This problem occurs not only in one place but has become a widespread challenge in primary mathematics education across various countries (Menaga, Cheng Meng, & Chin, 2022). According to Firdaus (2022), students' average ability in mathematical problem solving was only 42%. This relatively low achievement was attributed to learning practices that remained largely teacher-centered, the limited use of concrete instructional media, and insufficient student participation in classroom activities (Widyastuti et al., 2022).

In response to these low competencies, the Problem-Based Learning (PBL) model is considered an appropriate learning model because it uses real-world issues as learning triggers, thereby facilitating students to sharpen their critical reasoning skills and construct problem solutions (Leonardo Ii, 2024; Suparman, Juandi, & Tamur, 2021; Yuhana & Fajari, 2025). From a theoretical standpoint, the PBL model is grounded in constructivism, which posits that student understanding is formed most optimally when they actively construct their own knowledge through meaningful learning experiences (Subba, Chanunan, & Poonpaiboonpipat, 2025). Instead of acting as passive vessels, students are required to weave new information with their existing knowledge schemas. An added value of PBL is its ability to transform daily reality into an academic context. Consequently, taught concepts become more relevant, engaging, and applicable to students in the real world (Siregar, 2025).

This aligns with Jean Piaget's theory of cognitive development, in which children in elementary school enter the concrete operational stage. The main characteristic of this phase is the high effectiveness of information reception when assisted by physical objects that can be directly observed and manipulated. Students at this age level tend to find it difficult to digest fully abstract concepts without physical form. Therefore, the implementation of the PBL model will be far more effective when supported by concrete media that align with students' cognitive capacity (Byrne, Jensen, Thomsen, & Ramchandani, 2023; Dewanti, Rahmawati, & Sumardi, 2025; Lestari, Wahyudi, & Chamdani, 2023).

One instructional media considered relevant for integration into mathematics learning is the traditional game of congklak. This long-known game in Indonesian culture holds high educational value as it trains precise counting skills, attention to detail, and planned decision-making during play (Alvisari, Lah, & Tun, 2024; Hariyadi, Rasyad, Rondhi S, Santoso N, & Najikhah, 2024). Congklak is also effective in visualizing mathematical concepts often considered abstract, particularly factors and multiples, making them easier to understand concretely (Fatimah, Idawati, Astuti, Mahmudah, & Baiti, 2021; Kabuye Batiibwe, 2024). Various research findings consistently show that integrating game elements into learning positively impacts both student learning outcomes and problem-solving abilities (Susilawati, Sharov, Pasqa, & Malik, 2025; Wahyuni, Isrok'atun, & Maulana, 2024).

Research on PBL and instructional media has hitherto been conducted separately, leaving limited research that examines both in an integrated manner, especially regarding KPK and FPB topics in elementary schools. This gap underlies this study, which aims to measure and describe students' problem-solving abilities using Polya's stages and employs a quasi-experimental method. Based on the theoretical gaps and challenges described previously, the research problem of this study is: How effective is the application of the Problem-Based Learning model, assisted by the congklak game media, in improving the mathematical problem-solving ability of elementary school students, particularly in the KPK and FPB topics?

Building on this research problem, this study aims to empirically analyze the difference in effectiveness between implementing the PBL model integrated with traditional congklak media and the Discovery Learning approach, which has been the standard of teaching at the primary level. As an operational foundation in statistical analysis, the proposed hypotheses to be tested include:

H0**:** There is no significant difference in the improvement of mathematical problem-solving ability between elementary school students using the Problem-Based Learning (PBL) model assisted by the congklak game media and students using the Discovery Learning model for the KPK and FPB topics.

H1: There is a significant difference in the improvement of mathematical problem-solving ability between elementary school students using the Problem-Based Learning (PBL) model, assisted by the congklak game media, and students using the Discovery Learning model in the KPK and FPB topics.

Beyond testing quantitative hypotheses, this research aims to enrich the scientific literature on mathematics pedagogy and offer practical guidelines for educators. The collaboration between the PBL method and this concrete learning instrument is projected to create a classroom ecosystem design that is more participatory, meaningful, and fully student-centered.

METHOD

Participants

The target population for this study comprised all elementary school students in Purwakarta Regency. However, to maintain the validity of the research results and address technical limitations in the field, the sample was restricted to 52 students from a single public elementary school. Due to the localized sample and the inherent differences in educational environments across institutions, the current outcomes are strictly context-dependent and cannot be generalized broadly. Nevertheless, the findings remain valuable as a preliminary overview for future research.

Purposive sampling was used because the quasi-experimental design requires naturally formed groups (intact groups) rather than randomized groups (Creswell, 2018). Simple random sampling of individuals was not utilized because it could potentially disrupt ongoing teaching and learning activities and conflict with the school's administrative regulations.

Two classes were selected as samples based on three equivalence criteria: (1) students' active learning levels, (2) uniform curriculum content, and (3) proportionate class sizes. Active learning was evaluated through preliminary observations of student participation in Q&A, discussions, and assignments. Consequently, both classes demonstrated comparable profiles suitable for comparison. For a quasi-experimental design, this criteria-based selection is more appropriate than simple randomization as it ensures baseline equivalence prior to intervention.

However, since this assessment was purely observational, future research should use standardized instruments, such as validated questionnaires or rubrics, to confirm initial equivalence.

Research Design and Procedure

This research adopted a quasi-experimental approach using a Nonequivalent Control Group Design to evaluate the instructional model's impact on students' mathematical problem-solving skills. Based on this design, assessment was conducted using pre- and post-tests for both observation groups (Creswell, 2018). The pre-intervention involved completing a 60-minute, four-item essay instrument reconstructed based on Polya's stages comprising understanding the problem, devising a plan, executing the strategy, and looking back. The selection of this framework was based on its relevance for facilitating a systematic, logical cognitive flow during problem-solving (Dookurong et al., 2025).

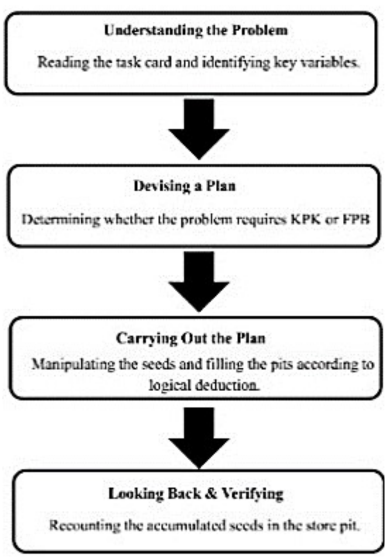

Figure 1. Flowchart using congklak media

For the experimental class, learning was implemented using a Problem-Based Learning (PBL) model, with congklak as a manipulable medium. The process began by presenting contextual problems to stimulate learning motivation. Students then worked in small collaborative groups to develop alternative solutions, where congklak helped transform the abstract concepts of KPK and FPB into concrete visual representations. Throughout the activity, students were encouraged to discuss, test strategies, and justify their reasoning. The session concluded with group presentations, followed by teacher-led synthesis and summary of key conclusions.

In contrast, the control class received instruction via the Discovery Learning approach. The lesson started with a stimulation stage to spark curiosity through real-world cases of KPK and FPB. Guided by Student Worksheets (LKPD), students identified key variables and formulated initial hypotheses. During data collection, students explored multiples and factors and subsequently processed this information to construct step-by-step mathematical solutions. Following cross-group presentations, the lesson concluded with teacher-guided concept generalization and a formative evaluation.

Upon concluding all intervention sessions, both classes completed a post-test designed with equivalent difficulty levels and measurement indicators to the pre-test. Data gathered from this stage were analyzed to measure gains in mathematical problem-solving competencies and to determine the comparative effectiveness between congklak-assisted PBL and the Discovery Learning model.

Instruments

The instrument in this study consists of four descriptive questions, presented in a grid table.

Before using the four research questions to measure students' abilities, these items need to be tested for validity and reliability. This test is important to conduct, given that a good instrument must accurately measure the construct targeted by the research (Ling, 2023). To ensure

Table 1. Research instrument grids

No	Question Indicator Problem-Solving Capabilities	Questions
1.	The ability of students to understand problems by writing down what they know and what is asked. (Understanding the Problem)	In the garden, there are two decorative lamps. Yellow lights flash once every 7 seconds, while green lights flash once every 5 seconds. Currently, both lights are flashing simultaneously. After how many seconds will the two lights flash at the same time again? Question: Write down what you know and what is asked in the story item!
2.	Students' ability to plan problem-solving with the right steps. (Planning the Solution)	Mom has 12 oranges and 18 apples. All the fruits will be put in several boxes. Each box should contain an equal number of oranges and apples, with no leftovers. What is the most boxes a mom can make? Question: Write down the steps of the completion plan to find out how many boxes you can make the most!
3.	Students' ability to carry out problem-solving plans carefully. (Implement the settlement plan)	Budi studies mathematics every 2 days and studies science every 3 days. Today he learned both. After how many days will Budi study mathematics and science at the same time again? Question: Based on the planned steps, carefully solve the problem above!
4.	The student's ability to re-examine the results of the completion and draw conclusions. (Checking back)	Ani has 10 chocolate candies and 15 strawberry candies. Ani wanted to divide all the candies into several bags, so that each bag contained the same number of each type of candy, with no leftovers. How many bags can Ani make? Question: Check back and draw conclusions from the answers you have completed!

data accuracy, the questions were analyzed for validity and reliability using ANATES 4.0 software for essay formats. This ANATES software presents the results of validity calculations based on the Pearson Product-Moment correlation, while for reliability it uses the Cronbach's Alpha formula. The calculation results indicated a high validity score of 0.64, indicating that the items accurately measure the intended variables. Meanwhile, the Cronbach's Alpha calculation yielded a coefficient of 0.80, confirming excellent internal consistency. Because these numbers confirmed that this tool produces stable results across similar testing scenarios, it was considered highly appropriate and scientifically reasonable for collecting primary data for this research. The achievement of these numbers indicates that this research instrument meets a high standard, in which the data produced remain consistent even when retested in comparable situations. Given the expected stability of the results, this instrument is considered highly suitable for data collection in research (Melaningsih, Ananda, Pahmi, & Kondologit, 2023).

Student answer analysis was carried out using an analytic scoring rubric based on four indicators aligned with Polya's problem-solving stages, with a maximum total score of 10 if all criteria are answered correctly. This assessment approach was chosen because it has been shown to increase objectivity and consistency in assessing mathematical problem-solving skills and to provide a more comprehensive picture of students' thinking processes (Salazar-Torres, Rincón Leal, & Vergel Ortega, 2021). Details of the scoring rubric are presented in the following table.

Table 2. Problem-Solving skills scoring rubric

Indicator	Answer Criteria	Score
Understanding the problem	Students do not write down the data that is known and asked about the given problem	0
	Students write down the data that is known and asked about the problems given, but it is not complete	1
	Students write down in full the data that is known and ask about the given problem	2
Planning the Solution	Students do not formulate problem-solving strategies	0
	Students misformulate problem-solving strategies	1
	Students formulate problem-solving strategies, but are not precise	2
	Students formulate problem-solving strategies appropriately	3
Implement the settlement plan	Students do not perform problem-solving procedures	0
	Students perform unclear problem-solving procedures	1
	The student performed a complete problem-solving procedure, but was wrong in the calculation	2
	Students perform the completion procedure appropriately	3
Checking back	Students do not rewrite the results of the recheck	0
	Students write but are not accurate	1
	Students write down correctly	2

Data Analysis Techniques

The data collected in this study were analyzed using IBM SPSS Statistics version 29. Prior to hypothesis testing, the pre-test and post-test scores were examined to determine whether they met the assumptions required for parametric statistical analysis. These preliminary analyses included tests of normality and homogeneity. Because the sample size was fewer than 50 participants, the Shapiro–Wilk test was used to assess the normality of the data. This test is considered appropriate for small sample sizes. In addition, Levene's test was conducted to examine the homogeneity of variance between the experimental and control groups.

After the data were confirmed to be normally distributed and homogeneous, an independent samples t-test was performed to determine whether there was a significant difference between the two groups at the 0.05 significance level. If the data had not met the assumptions of normality or homogeneity, the Mann–Whitney U test would have been used as a non-parametric alternative.

Normality testing is important because it helps determine whether the sample data adequately represent the population from which they were drawn (Gosselin, 2024; Orcan, 2020). When the normality assumption is satisfied, the results of parametric statistical tests can be interpreted with greater confidence (Ibironke, Oyebade, & Sulaimon, 2026).

To measure the improvement in students' mathematical problem-solving ability after the learning intervention, the Normalized Gain (N-Gain) test was also conducted. The N-Gain score was calculated using the difference between students' pre-test and post-test scores, allowing the magnitude of learning improvement to be identified.

RESULT AND DISCUSSION

Derived from the mathematical problem-solving assessments of V-grade elementary school students, the dataset comprises two classes, each containing 26 individuals. To visually illustrate the shifts in student performance pre- and post-intervention, Figure 2 presents a box plot comparing the distribution of pretest and posttest scores across the experimental and control classes.

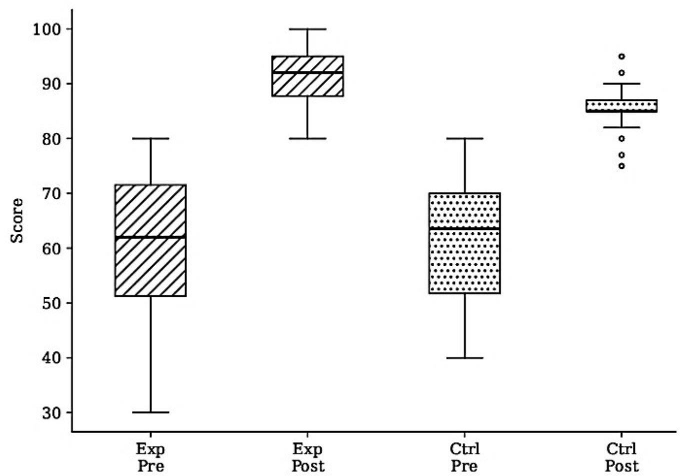

Figure 2. Box plot: student score improvement

As observed in Figure 2, the initial score distributions of both groups were largely comparable, characterized by aligned medians and similar interquartile ranges. Post-intervention, the experimental class's distribution exhibited a pronounced upward shift in scores and a narrower range, indicating that a majority of students consistently attained high marks with minimal variance. Conversely, while the control class experienced a rise in its posttest median, the magnitude of improvement was less substantial, and the data retained high variability, as evidenced by several outliers beyond the whiskers. This trend indicates that the intervention applied to the experimental group was considerably more effective at yielding consistent score improvements than the conventional teaching methods utilized in the control group. Furthermore, to provide a more granular analysis of the score distributions by interval, the pretest and posttest data for both classes have been categorized into a frequency distribution, as detailed in Table 3 below.

Table 3 indicates that both classes had similar initial abilities on the pretest, with most students scoring in the middle range (62–77).

Table 3. Frequency distribution

Pre-test				Post-test			
Class Experiments		Class Controls		Class Experiments		Class Controls	
Interval	fi	Interval	fi	Interval	fi	Interval	fi
30-37	1	30-37	0	74-77	0	74-77	2

38-45	3	38-45	4	78-81	2	78-81	1
46-53	3	46-53	3	82-85	1	82-85	13
54-61	5	54-61	5	86-89	4	86-89	4
62-69	6	62-69	5	90-93	7	90-93	4
70-77	7	70-77	8	94-97	7	94-97	2
78-85	1	78-85	1	98-100	5	98-100	0

However, the posttest data reveal a distinct divergence. The experimental class saw its highest frequencies in the top-tier intervals of 90–93 (fi = 8) and 94–97 (fi = 7), with 5 students achieving the maximum 98–100 range. Meanwhile, the control class peaked at a lower interval of 82–85 (fi = 13), with no students reaching the highest bracket. This distributional shift reinforces earlier findings from Figure 2 and Table 3, demonstrating that the PBL intervention in the experimental class led to higher, more evenly distributed improvements in mathematical problem-solving skills than in the control class.

As shown in Table 4, the initial capabilities of both groups were highly comparable. The marginal difference in the pretest scores between the experimental and control classes demonstrates this. Establishing this baseline equivalence is crucial, as it ensures that any subsequent disparities in final scores can be attributed strictly to the instructional methods used, rather than to preexisting differences in student proficiency.

Table 4. Descriptive statistics

Classes	Data	Score			Std.
		Min	Max	Mean	Deviation
Controls	Pretest	40	80	61.54	12.741
	Posttest	75	95	85.81	4.605
Experiments	Pretest	30	80	60.46	13.369
	Posttest	80	100	92.15	5.836

Although performance metrics improved across both student groups after the intervention phase, the magnitude of academic growth within the Problem-Based Learning (PBL) experimental cohort vastly exceeded that of the Discovery Learning control group. Ultimately, these empirical results substantiate the premise that coupling the PBL framework with congklak manipulatives not only successfully cultivates mathematical problem-solving proficiencies, but it also delivers substantially better educational outcomes than standalone Discovery Learning strategies.

The normality test was performed as a prerequisite for parametric hypothesis testing to verify that the distribution of mathematical problem-solving ability data in both groups was normal. (Gosselin, 2024). Because the number of samples in each group was only 26 ($n<50$ students), the results of the Shapiro-Wilk test were used as the main reference, as this method is considered more appropriate for small samples. Based on the significance criterion $(p) > 0.05$, the data are considered normally distributed, meeting the assumption of parametric statistics.

Table 5. Normality test

Classes	Shapiro- Wilk		
Results	Statistic	df	Sig.
Pre-test Experiment	.951	26	.249
Post-test Experiment	.933	26	.090
Pre-test Control	.923	26	.054
Post-test Control	.922	26	.050

Before proceeding to the different tests, the validity of the data must be ensured through prerequisite testing. Based on the data in Table 5, the results of the Shapiro-Wilk test indicate that all data groups have p-values above the threshold of 0.05: experimental pre-test p = 0.249, experimental post-test p = 0.090, pre-test control p = 0.054, and post-test control p = 0.050. After the normality assumption is met, a homogeneity test is performed. These results also show that the conclusions from the hypothesis testing based on sample data can be generalized to the population.

After normality testing, the analysis continues with the homogeneity of variance test. This stage of testing, using Levene's Test for Equality of Variances, aims to assess whether population variances are equal. The decision criterion is simple: if the significance value (p) > 0.05, then the variance of the two groups is declared homogeneous.

Table 6. Test of homogeneity

Levence Statistic	df1	df2	Sig.
2.655	1	50	.109

Referring to Table 6, the results of the Levene test show F(1, 50) = 2.655 with p = 0.109. Because the significance value obtained is greater than 0.05, it can be concluded that there is no significant difference in variance between the experimental and control classes. Thus, the assumption of homogeneity is declared met. Both groups show comparable levels of variability, so the comparison between the two can be conducted objectively using statistical tests that assume equal variances.

Next, the Independent Samples t-test is conducted to determine whether there is a difference in mathematical problem-solving ability between the experimental and control classes.

Table 7. Independent samples test

Classes	Data	t-test for Equality of Means		
		t	df	Sig. Two-Sided p
Experiments Controls	Pretest	0.297	50	0.767
Experiments Controls	Posttest	-4.353	50	<0.001

The Independent Samples T-Test on the pre-test data yielded a significance value of 0.384, which far exceeded the 0.05 significance level. These findings confirm that, before the treatment was administered, the two classes had equal ability and showed no significant difference. This picture is important because it ensures that the final result reflects the treatment's effect rather than differences in initial ability.

In contrast to the pre-test results, the post-test data show a much different variation. The significant result was <0.001, indicating that after the learning process, there was a difference in mathematical problem-solving ability between students in the experimental and control classes. The average advantage of the experimental class provides strong evidence that Problem-Based Learning, assisted by the congklak game media, is more effective than Discovery Learning model.

To determine the magnitude of improvement in students' mathematical problem-solving skills for each indicator following the intervention, an N-Gain analysis was conducted on the pretest and posttest scores of both the experimental and control classes. The N-Gain calculation results for each indicator of mathematical problem-solving skills are presented in Table 8 below.

Table 8. N- Gain

Classes	Indicators of Mathematical Problem-Solving Skills			
	Understanding the problem	Planning the Solution	Implementing the solution plan	Checking back
Experiments	0.98	0.92	0.81	0.52
Controls	0.97	0.72	0.66	0.45

All indicators improved in both groups, with the experimental class consistently outperforming the control class. The largest gaps appeared in the indicator of planning the solution (0.92 vs 0.73) and implementing the settlement plan (0.81 vs 0.66). In contrast, the understanding-the-problem indicator showed nearly equal results between the two groups (0.98 vs 0.975), and checking back was the only indicator classified as moderate in both classes (0.53 vs 0.46). These findings provide evidence that implementing the Problem-Based Learning model, assisted by the congklak game, significantly improves students' problem-solving abilities following the instructional treatment.

The results of this research indicate that integrating the congklak game into a Problem-Based Learning approach yields greater improvements in students' math problem-solving skills than the Discovery Learning model. Students in the experimental class obtained an average post-test score of 92.15, exceeding the control class's mean of 85.81. Statistical analysis using the Independent Samples t-Test revealed a significance value below 0.05 ($p < 0.001$), confirming a significant difference between the two groups.

The N-Gain analysis reveals a widening gap in the later stages of problem-solving. This confirms that elementary students' performance across Polya's four stages declines as complexity increases, particularly in the most difficult stages of planning and checking back (Riyadi, Syarifah, & Nikmaturrohmah, 2021). Consequently, the findings demonstrate that a Problem-Based Learning model using congklak media significantly outperforms the Discovery Learning approach in enhancing students' problem-solving abilities.

The effectiveness of this Problem-Based Learning (PBL) framework is supported by the principles of contextual theory and cognitive psychology (Alfayez, Aladwan, & Shaheen, 2022). Rather than passively receiving knowledge from their instructors, learners actively participate in dialogues, examine issues, and independently discover solutions. Furthermore, consistent participation in such exercises enhances critical thinking skills, enabling students to better identify, evaluate, and solve mathematical challenges.

The outcomes of this research align with prior literature, indicating that the Problem-Based Learning (PBL) approach enhances critical thinking and mathematical problem-solving capabilities. This improvement is achieved by immersing learners in purposeful evaluative and analytical exercises during instruction (Manuaba, No, & Wu, 2022; Zin, 2023). Compared to conventional learning, PBL has been shown to produce achievements that further improve students' mathematical thinking skills (Laine, 2022).

Using concrete manipulatives in elementary mathematics effectively bridges the gap between tangible and abstract concepts. Here, the traditional congklak serves as a practical cognitive scaffold. Physically moving the seeds helps students grasp arithmetic operations and guides them through Polya's four stages of problem solving. The integration of the congklak manipulative serves as a facilitator, aligning students' cognitive processes with Polya's four stages of problem resolution. In the initial phase (understanding the problem), each group is provided with a contextual problem card and a set of congklak boards. By analyzing the problem's narrative, learners identify the essential variables and the core question. Moving into the strategy design phase, students dissect the story's context to determine the most appropriate mathematical approach, such as KPK or FPB, as needed. Establishing this strategy is an absolute prerequisite before any movement of the congklak seeds.

The third step, implementing the plan, is tangibly executed through a simulation of distributing or grouping the congklak seeds into the small holes according to the selected operational rules. Through this hands-on practice, the complexity of previously abstract mathematical concepts is successfully transformed into an easily observable visual procedure. Finally, during the evaluation stage (looking back), students validate their answers by calculating the accumulation of seeds in the main storehouse. This verification process ensures that the learning tool's output aligns with the initial solution design. Ultimately, the entire sequence of operational activities using the congklak media from reading the problem to the final calculation in the main hole serves as a physical manifestation of Polya's framework, explicitly illustrating the mechanism of this intervention.

Moving on to carrying out the plan, students actively dropped the seeds into the board's pockets, ensuring their actions matched the numbers from the story card. This hands-on activity acted as a concrete calculator, helping them discover the KPK or FPB visually and avoiding the mental strain usually caused by abstract formulas (Koskinen & Pitkäniemi, 2022). For the final checking back step, the children did not rely on recalculating complex written equations. They simply looked at the final distribution of the seeds to confirm if their answer aligned with the original question. This direct visual feedback built their confidence and reinforced their understanding (Melaningsih et al., 2023). Furthermore, using a familiar cultural game created a relaxed atmosphere that kept students motivated and actively involved (Sunzuma, Zezekwa, Gwizangwe, & Zinyeka, 2021). Ultimately, this method turned abstract math concepts into a highly meaningful and relatable experience for young learners.

CONCLUSION

The results of this study indicate that the application of the Problem-Based Learning (PBL) model, combined with the congklak game as a learning medium, is effective in improving the mathematical problem-solving skills of elementary school students, especially in the material on KPK and FPB. This improvement occurred due to a change in the way of learning in the classroom. Students no longer merely receive material passively, but actively solve problems in groups. This active involvement deepens students' understanding of mathematics. Furthermore, the congklak medium helps connect abstract mathematical concepts to students' real experiences, making learning feel more concrete and enjoyable.

Based on these findings, elementary school teachers are advised to consider the traditional game-based PBL model as an approach in teaching KPK and FPB. Student-centered learning has been shown to make the classroom atmosphere more active and meaningful. In addition, schools need to support the development of innovative learning media like this. This approach is not only beneficial for improving mathematics learning outcomes, but also helps preserve local cultural values among students.

Nevertheless, this study has several limitations that should be considered when interpreting the results and designing future research. First, this study involved only 52 students from one public elementary school, so the results cannot yet be generalized to other schools with different characteristics. Second, the duration of the congklak-based PBL intervention in this study was relatively short, so it is not yet known whether the improvement in students' problem-solving skills can be sustained in the long term after the intervention ends. Third, this study only focused on KPK and FPB materials, so it is not yet known whether this approach is also effective for other mathematical topics.

Based on these limitations, future research is recommended to use a larger sample originating from various schools with more diverse characteristics, so that the results can be generalized more broadly. Research with a longer intervention duration is also needed to determine whether the impact of congklak-based PBL can be sustained over time. In addition, future research is advised to test the application of this PBL model to other mathematical materials and at different educational levels, to strengthen evidence of its effectiveness more broadly.

■ DECLARATION GENERATIVE AI USAGE IN THE WRITING PROCESS

During the preparation of this manuscript, the authors employed generative artificial intelligence (AI), specifically Claude (claude.ai), to a limited extent. AI assistance was strictly utilized for proofreading and language refinement. Additionally, the tool was used to ensure citation consistency with the reference list and to assist in formatting responses to peer-review comments. All resulting outputs were thoroughly evaluated, fact-checked, and refined prior to final inclusion. Consequently, the authors take full responsibility for the validity, authenticity, and overall integrity of the content presented herein.

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