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Improvement in elementary students' mathematical problem-solving abilities through contextual teaching and learning supported by Geoboard media

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Improvement in elementary students' mathematical problem-solving abilities through contextual teaching and learning supported by Geoboard media

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ABSTRACT

Mathematical problem-solving ability is a crucial competency in elementary school mathematics education. However, low levels of learning activity and a lack of instructional variety remain challenges in developing this ability, particularly regarding the topic of 2-dimensional (2D) shapes. This study aimed to analyze changes in students' mathematical problem-solving abilities following instruction using the Contextual Teaching and Learning (CTL) approach assisted by geoboards, and to examine the relationship between learning activity and mathematical problem-solving scores. A quantitative approach was employed using a pre-experimental one-group pretest-posttest design. The study subjects consisted of 40 fourth-grade students from primary school (SD) 5 Ngabul. Data were collected using a mathematical problem-solving test based on Polya's stages and an observation sheet for student learning activity. Data analysis was conducted using the Paired Sample T-test and simple linear regression. The results showed an increase in the average mathematical problem-solving score from 41.85 to 70.13 following the instruction. Furthermore, student learning activity showed a positive relationship with posttest scores, with a coefficient of determination of 56.1% for the study sample. The findings indicate that CTL instruction assisted by geoboards serves as a viable alternative teaching method to foster student engagement and the development of mathematical problem-solving skills.

Keywords: Contextual Teaching and Learning, Geoboard, Mathematical Problem Solving Skills, Mathematics Learning

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INTRODUCTION

Mathematics education is a subject of great importance for students Ramandani et al., (2026). Mathematics is a discipline that fosters logical thinking, reasoning, and analytical skills, enabling individuals to find solutions to various problems encountered in daily life (Ardi et al., 2025). Furthermore, mathematics serves to explain everyday experiences by addressing problems related to social, cultural, and natural environmental aspects (Zuliana, 2023). Thus, mathematics can be regarded as a discipline that equips individuals with the ability to solve problems and devise solutions in their daily lives. The significance of this ability is also underscored by the National Council of Teachers of Mathematics (NCTM), which states that

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mathematics instruction should not merely focus on mastering fundamental concepts but should also aim to develop students' problem-solving skills (Wahyuni et al., 2024).

Mathematical problem-solving ability can be developed through skills such as understanding the problem, constructing mathematical models, solving the problem, and interpreting the solution in accordance with indicators of mathematical problem-solving proficiency (Ramadhani et al., 2024). Problem-solving ability is a crucial competency to cultivate in mathematics education. However, results from the 2015 TIMSS (Trends in International Mathematics and Science Study) indicate that student achievement in Indonesia remains low, as evidenced by the country ranking 44th out of 49 participating nations (Hidayah et al., 2024). Furthermore, student learning activity is a significant factor in the success of mathematics learning. Learning activity encompasses the processes of gathering knowledge and information, enhancing understanding, developing skills, and transforming attitudes (Cahyani & Pranata, 2023). According to Arafah et al., (2024), learning activities include visual, oral, listening, writing, drawing, motor, mental, and emotional actions that demonstrate student engagement in the learning process. Active students tend to find it easier to grasp concepts, construct knowledge, and develop the thinking skills necessary for problem-solving.

Observations and interviews at primary school (SD) 5 Ngabul reveal that the instructional process is dominated by the lecture method and lacks variety; teachers frequently rely on verbal explanations, and the use of instructional media is suboptimal. Consequently, students tend to be passive, contribute little to learning activities, and lack enthusiasm during lessons. This low level of engagement hinders students' ability to grasp mathematical concepts and solve problems requiring problem-solving skills; furthermore, average daily test scores have failed to meet the established learning mastery criteria. Pre-research data indicate that 45% of students achieved the mastery score, while 55% did not.

To address these issues, an appropriate learning model is required to enhance the quality of the learning process and improve students' mathematical problem-solving skills (Endry et al., 2025). One model considered relevant is Contextual Teaching and Learning (CTL). The CTL model emphasizes active student engagement in constructing knowledge by linking learning materials to real-life situations relevant to their own lives (Ester et al., 2023). Consequently, students not only grasp concepts theoretically but also gain the ability to apply them to solve various mathematical problems (Nurhanipah et al., 2025). In addition to employing a suitable learning model, the use of appropriate learning media is a crucial factor in supporting the learning process. One such medium applicable to the topic of 2D shapes is the geoboard. A geoboard serves as a tool for teaching geometric concepts-such as identifying 2D shapes, understanding perimeter, and calculating or determining the area of a shape (Mufidah et al., 2024). Utilizing this medium is considered relevant because many students still struggle to recognize and classify various 2D shapes (Zuliana et al., 2026).

Several previous studies indicate that the CTL model and geoboard media have the potential to enhance students' mathematical problem-solving skills. Similar results were found by Juita et al., (2023), demonstrating that CTL could improve problem-solving skills regarding division operations. Research by Yoyana and Supriansyah, (2025) showed that the use of geoboard media helped students build a more concrete understanding of 2D shape concepts through direct visualization, thereby making the concepts easier to grasp. These findings suggest that the CTL model and geoboard media offer viable alternatives for instruction aimed at improving students' mathematical problem-solving skills.

Although various studies have demonstrated that the Contextual Teaching and Learning (CTL) model and geoboard media can enhance students' learning outcomes and mathematical problem-solving skills, most of this research has focused on the impact of the learning model on these outcomes or skills without examining the factors that facilitate such improvement during the learning process. Research integrating the CTL model with geoboard media while

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simultaneously analyzing the contribution of student learning activities to mathematical problem-solving skills remains relatively limited, particularly among fourth-grade elementary school students. Therefore, this study offers a novel contribution by not only examining improvements in mathematical problem-solving skills through the CTL model supported by geoboard media but also analyzing the contribution of student learning activities to these skills using simple linear regression analysis.

Based on the preceding explanation, the research problem addresses whether there is a significant difference in students' mathematical problem-solving abilities before and after undergoing instruction using the Contextual Teaching and Learning (CTL) model assisted by geoboards, as well as the extent to which student learning activities contribute to these abilities following the instruction. Therefore, this study aims to determine the improvement in the mathematical problem-solving abilities of fourth-grade students at primary school (SD) 5 Ngabul through the CTL model assisted by geoboards and to assess the contribution of student learning activities to these abilities after the instruction.

METHOD

This study aims to analyze the improvement in students' mathematical problem-solving skills following instruction using the Contextual Teaching and Learning (CTL) approach supported by geoboard media, as well as to determine the contribution of student learning activities to these skills. The study employs a quantitative approach with a pre-experimental design-specifically, a One-Group Pretest-Posttest Design. This design is used to observe changes in students' mathematical problem-solving abilities before and after the implementation of the CTL intervention using geoboards. The research was conducted at primary school (SD) 5 Ngabul in Tahunan District, Jepara Regency, Central Java, during the even semester of the 2025/2026 academic year. The research subjects consisted of all 40 fourth-grade students, selected using a saturated sampling technique. Prior to the intervention, mathematics instruction was dominated by the lecture method-resulting in passive student engagement-and the use of instructional media was suboptimal.

The research was conducted in three stages: administering a pretest, implementing geoboard-assisted CTL (Contextual Teaching and Learning) instruction over three sessions, and administering a posttest. The instructional content covered polygons, triangles, and quadrilaterals. The researcher conducted the lessons by applying the CTL framework, which encompasses Constructivism, Inquiry, Questioning, Learning Community, Modeling, Reflection, and Authentic Assessment. During the learning process, students used geoboards-consisting of pegboards and rubber bands-to construct, observe, and analyze various 2D shapes and to solve contextual problems. Lesson implementation was monitored using observation sheets to ensure that the CTL stages and the use of geoboards proceeded according to the plan.

Data collection was carried out through interviews, observations, tests, and documentation. Interviews were conducted with the fourth-grade teacher and three students to gather preliminary information regarding the state of mathematics instruction and the challenges faced by the students. Observations were used to collect data on student learning activities during CTL-based lessons utilizing geoboards, focusing on eight indicators of learning activity-visual, oral, listening, writing, drawing, motor, mental, and emotional-recorded via an observation sheet using a Likert rating scale. The mathematical problem-solving ability test consisted of five essay questions developed based on Polya's four problem-solving indicators: understanding the problem, devising a plan, carrying out the plan, and looking back (reviewing the results). Scoring was performed using a problem-solving rubric with a scale of 0 to 4. Prior to use, all instructional materials and research instruments underwent expert validation by four validators-comprising university lecturers and fourth-grade teachers-to assess the appropriateness of content, construct, and language. Validation

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results indicated that the instruments met the criteria for excellent suitability. Documentation was used to supplement the research data, including student rosters, grades, photographs of learning activities, and other supporting documents.

Data analysis was conducted using statistical software. The initial analysis involved calculating scores for the pretest, posttest, and student learning activities. Subsequently, a normality test using the Shapiro-Wilk method was performed to determine whether the data followed a normal distribution; data were considered normally distributed if the significance value exceeded 0.05 (Ghozali & Kusumadewi, 2023). Upon satisfying the normality assumption, a Paired Sample T-Test was conducted to determine whether there was a difference in students' mathematical problem-solving abilities before and after the implementation of the CTL model assisted by geoboard media (Sugiyono, 2019). Next, a simple linear regression analysis was performed to address a different research question: determining the contribution of student learning activities to mathematical problem-solving abilities following the instruction. In the regression analysis, learning activity served as the independent variable (X), while the posttest score for mathematical problem-solving ability served as the dependent variable (Y). Thus, the paired t-test was used to assess the improvement in mathematical problem-solving abilities before and after the intervention. In contrast, the regression analysis was used to determine the contribution of learning activities to that ability. All statistical tests were conducted using a significance level of 0.05.

The instruction was conducted over three sessions focusing on 2D shapes, specifically polygons, triangles, and quadrilaterals. The lessons employed the Contextual Teaching and Learning (CTL) model, comprising seven components: Constructivism, Inquiry, Questioning, Learning Community, Modelling, Reflecting, and Authentic Assessment (Telaumbanua et al., 2025). Geoboards served as visual aids to help students directly explore the shapes, properties, perimeters, and areas of these figures. During the Constructivism stage, students observed images of 2D shapes found in everyday life and connected them to their prior knowledge. Next, in the Inquiry stage, students used geoboards to observe and construct shapes, enabling them to discover concepts independently. In the Questioning stage, students actively asked and answered questions related to the topic. During the Learning Community stage, students collaborated in groups to solve assigned problems and presented their findings to the class. The teacher demonstrated systematic problem-solving using the geoboard during the Modeling stage. Subsequently, in the Reflecting stage, students articulated their conclusions and reviewed their completed work. Finally, in the Authentic Assessment stage, the teacher evaluated the students' learning activities and work outcomes.

RESULT

1. Normality Test

The data analyzed in this study were derived from the pretest and posttest results measuring the mathematical problem-solving skills of fourth-grade students at primary school (SD) 5 Ngabul. Before testing the hypotheses, a normality test was first conducted to determine whether the research data were normally distributed. The results of the normality test are presented in the following Table 1.

Based on the Shapiro-Wilk normality test results presented in the table above, the significance value for the pretest was 0.419, while the significance value for the posttest data was 0.144. Since the Shapiro-Wilk significance values for both the pretest and posttest were greater than 0.05, the data are normally distributed and meet the requirements for hypothesis testing using the Paired Sample T-Test.

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Table 1. Results of the Normality Test for Pretest and Posttest Data

Tests of Normality						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.099	40	.200*	.972	40	.419
Posttest	.122	40	.138	.958	40	.144

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Source: Researcher Data (2026)

2. Paired Sample T-Test

Table 2. Paired Sample T-Test Results

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Pretest - Posttest	-28.275	9.078	1.435	-31.178	-25.372	-19.699	39	.000

Source: Researcher Data (2026)

In addition to the paired-sample t-test, this study also employed simple linear regression to examine the effect of the geoboard-assisted CTL model on mathematical problem-solving skills. The simple regression analysis was conducted using students' learning activity scores during lessons using the CTL model and their posttest scores on mathematical problem-solving skills.

3. Simple Linear Regression Test

In addition to analysis using the Paired Sample T-Test, this study also used a simple linear regression test to determine the effect of the geoboard-assisted CTL model on mathematical problem-solving abilities. In this study, a simple regression test was conducted using students' learning activity scores using the CTL model and the results of the posttest scores on mathematical problem-solving abilities.

Table 3. Simple Regression Test Results - Model Summary

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.749[a]	.561	.549	10.475

a. *Predictors: (Constant)*, Student Learning Activities

Source: Researcher Data (2026)

Based on the analysis results in the Model Summary table, an R-value of 0.749 was obtained, indicating a strong relationship between students' learning activities and their mathematical problem-solving abilities. Furthermore, the R-square value of 0.561 indicates

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that students' learning activity scores explain 56.1% of the observed variation in mathematical problem-solving ability scores (pretest-posttest) within this study's sample.

Table 4. Results of the Simple Regression Test using the ANOVA Model

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5318.816	1	5318.816	48.474	.000[b]
	Residual	4169.559	38	109.725		
	Total	9488.375	39			

a. *Dependent Variable*: Posttest Value

b. *Predictors: (Constant)*, Student Learning Activities

Source: Researcher Data (2026)

Based on the results of the ANOVA analysis, a significant calculated F-value of 48.474 was obtained, with a significance level of 0.000 < 0.05. Since the significance level is 0.000 < 0.05, these results indicate that student learning activities have a significant effect on students' posttest scores in mathematical problem-solving skills.

Table 5. Simple Regression Test Results: Model Coefficients

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	-71.847	20.459		-3.512	.001
	Student Learning Activities	1.785	.256	.749	6.962	.000

a. Dependent Variable: Posttest Value

Source: Researcher Data (2026)

Based on the analysis results in the "Coefficients" table, a significance value of 0.001 was obtained. Since this value is smaller than the significance level of 0.05 (0.001 < 0.05), H_0 is rejected, and H_a is accepted. These results indicate that student learning activity has a significant effect on students' mathematical problem-solving ability. Furthermore, the linear regression coefficient indicates a positive relationship, meaning that the higher the students' learning activity, the higher their mathematical problem-solving ability.

DISCUSSION

Improvement in Mathematical Problem-Solving Skills Following the Implementation of the Contextual Teaching and Learning (CTL) Model Assisted by Geoboard Media

The research results indicate an improvement in students' mathematical problem-solving skills after participating in instruction using the CTL model assisted by geoboard media. A comparison of the mean scores from the pretest and posttest, analyzed via a Paired Sample T-Test, reveals that the mean pretest score prior to the implementation of the geoboard-assisted CTL model was 41.85. Following the intervention, the mean posttest score for mathematical problem-solving skills was higher, at 70.13. Thus, there was an increase of 28.28 in the mean score. This improvement demonstrates a significant change in students' mathematical problem-solving skills resulting from the intervention involving instruction based on the CTL model assisted by geoboard media.

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This improvement in ability can be explained by the characteristics of the CTL model, which positions students as active participants in constructing understanding through meaningful learning experiences. When learning about 2D shapes, students do not merely receive concepts from teacher explanations; instead, they connect these concepts to real-life situations, explore using geoboards, engage in discussions, and articulate their ideas. This process enables students to develop skills in comprehending problems, determining solution strategies, and applying mathematical concepts in diverse contexts. The use of geoboards further supports the learning process by helping students visualize 2D shapes more concretely.

Figure 1. Contextual Teaching and Learning (CTL) Conditions Assisted by Geoboard Media (Source: Researcher's Data, 2026)

Figure 2. The Use of Geoboards for Teaching 2D Shapes (Source: Researcher's Data, 2026)

Based on the learning documentation, students were observed actively discussing and using geoboards to construct and identify the characteristics of 2D shapes. This activity provided a more concrete learning experience, thereby helping students grasp the mathematical concepts being studied. Furthermore, students actively asked questions, engaged in discussions, and collaborated with their group members to solve mathematical problems. Consistent with this, Destiara et al., (2023) state that the use of geoboards in mathematics instruction can significantly enhance students' mathematical problem-solving abilities.

The development of mathematical problem-solving skills is also evident through the lens of George Polya's framework, which outlines a four-stage process: understanding the problem, devising a plan, carrying out the plan, and looking back (Indriani et al., 2023). Regarding the "understanding the problem" indicator, students found it easier to comprehend the problems presented. Prior to instruction using the CTL model supported by geoboards, some students struggled to identify the given information and the specific questions asked in the problems. Following the instruction, students became capable of accurately noting down key information from the problems. Regarding the "devising a plan" indicator, students began to plan their problem-solving strategies more effectively. During the pretest, some students wrote down answers without determining appropriate solution steps; however, after implementing the CTL model with geoboards, they were able to identify the relevant 2D shape concepts needed to solve the problems.

Regarding the problem-solving indicator, students demonstrated progress in their ability to solve problems. They were not only able to determine the correct answer but also

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began to explain the underlying reasoning. This was evident in their post-instruction work, where they could more systematically link the characteristics of 2D shapes to the solutions provided. Regarding the indicator of reviewing results, students' ability to verify their solutions also began to improve. Prior to the intervention, some students failed to state a conclusion or check their answers; however, following instruction using the CTL model supported by geoboards, they began to write conclusions that habitually aligned with their solutions.

The results of this study align with the research of Muslihah and Suryaningrat, (2021) which indicates that the Contextual Teaching and Learning (CTL) model can enhance students' mathematical problem-solving abilities. Research by Muhartini et al., (2023) also explains that contextual learning helps students build understanding by linking subject matter with everyday life experiences. However, the score improvements observed in this study must be interpreted with caution, as the research employed a one-group pretest-posttest design without a control group. Consequently, the changes in scores cannot be attributed solely to the implementation of the geoboard-assisted CTL model; they may also be influenced by other factors, such as the experience gained from taking the pretest, exposure to similar types of questions, natural skill development during the learning process, and teacher assistance provided during instruction.

The Relationship Between Student Learning Activity and Mathematical Problem-Solving Ability

In addition to analyzing the improvement in mathematical problem-solving ability by comparing pretest and posttest scores, this study also examined the relationship between student learning activity and mathematical problem-solving ability using simple linear regression analysis. The regression results yielded an R-value of 0.749 and an R-squared value of 0.561. These values indicate that student learning activity scores account for 56.1% of the observed variance in the posttest scores for mathematical problem-solving ability within the study sample. Meanwhile, 43.9% of the variation in posttest scores is attributable to other factors not analyzed in this study.

The relationship between learning activities and mathematical problem-solving ability can be explained through student engagement during the Contextual Teaching and Learning (CTL) process supported by geoboard media. Learning activities-encompassing visual, oral, listening, writing, drawing, motor, mental, and emotional actions-demonstrate that students are actively involved in constructing knowledge. Activities such as observing contextual problems, using geoboards, discussing, asking questions, expressing opinions, and reflecting provide students with opportunities to gain a deeper understanding of concepts and develop problem-solving strategies. Active student engagement during instruction is a key factor supporting the development of mathematical problem-solving skills. Students who are active in the learning process have greater opportunities to think, connect information, test solution strategies, and evaluate their results. These findings align with research by Rimalita et al., (2023) and Novika et al., (2023), which indicates that higher levels of student learning activity correlate with better mathematical problem-solving abilities.

Furthermore, learning activity is not the sole factor influencing post-test results, as there are other factors outside the scope of the study that contribute to students' mathematical problem-solving abilities. These factors can be categorized as either internal or external to the student. Internal factors include students' prior mathematical knowledge, learning motivation, and learning interest. Additionally, the learning process-involving teacher guidance and direction-can assist students in comprehending the material and solving mathematical problems. Prior mathematical knowledge enables students to connect their existing knowledge with the new concepts being learned (Zakiyah & Noor, 2022). Moreover, learning motivation encourages students to engage in understanding problems and attempting various solution strategies actively (Hasanah et al., 2024). Student interest in learning is also crucial, as it

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reflects a student's inclination to feel interested, enjoy the process, and be motivated to participate in learning activities (Asri et al., 2023).

In addition to internal student factors, external factors within the learning process can also influence the development of students' mathematical problem-solving skills. In this study, the implementation of the Contextual Teaching and Learning (CTL) model, supported by geoboard media, provided learning experiences through direct exploration, discussion, and problem-solving activities. However, students' success in solving mathematical problems can also be influenced by their readiness to engage with the lesson, their ability to adapt to group activities, and their prior experience in learning mathematics. Students with better prior learning experiences tend to find it easier to connect new concepts with their existing knowledge. Therefore, the improvement in mathematical problem-solving skills observed after instruction should not be viewed merely as the result of a single factor, but rather as the outcome of the interaction among various mutually supportive factors throughout the learning process. This indicates a link between learning activities and mathematical problem-solving skills; however, other aspects require further investigation to gain a more comprehensive understanding of the factors influencing these skills.

Although the Contextual Teaching and Learning (CTL) model, supported by geoboard media, positively influences students' mathematical problem-solving abilities, this study has certain limitations. The instructional process using the CTL model requires more time due to its extensive set of procedural steps (syntax), each of which must be executed sequentially to ensure optimal results; consequently, the learning process takes longer than conventional instruction. This aligns with Sarwari and Kakar, (2023), who noted that the CTL model demands significant time and energy and is less effective when implemented in large classes. Research by Nurjehan et al., (2024)also revealed that the CTL model could not be fully implemented across all its stages-particularly the "learning community" phase-in an optimal manner. Furthermore, as this study was conducted with a single class and a limited sample size, the findings cannot be generalized to reflect broader conditions.

CONCLUSION AND SUGGESTIONS

Based on the research findings and data analysis, it can be concluded that the implementation of the Contextual Teaching and Learning (CTL) model supported by geoboard media can improve fourth-grade students' mathematical problem-solving skills at Primary School (SD) V Ngabul. The learning approach provides students with opportunities to engage actively with mathematical concepts through contextual and hands-on activities, making the learning process more meaningful. The findings also indicate that students' learning activities during instruction are associated with their mathematical problem-solving performance. Thus, the integration of CTL and geoboard media offers a promising alternative for creating active, contextual, and meaningful mathematics learning experiences.

Nevertheless, this study has certain limitations that should be considered. As a one-group pretest-posttest design without a control group was employed, the observed improvements cannot be definitively attributed solely to the implementation of the geoboard-assisted CTL model. Therefore, future research should utilize a design that incorporates a control group and a larger sample size to gain a more robust understanding of the model's effectiveness. Additionally, subsequent studies could examine other factors related to mathematical problem-solving skills, such as learning motivation, prior mathematical knowledge, and student interest. In terms of instructional practice, the geoboard-assisted CTL model offers a viable alternative for creating a more active, contextual, and meaningful mathematics learning experience, provided that student characteristics and classroom conditions are taken into account.

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