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# The Effect of Contextual Teaching and Learning and Discovery Learning on Elementary Students' Mathematical Understanding

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**Abstract**

For elementary school students, grasping mathematical principles is an essential skill required to apply the subject meaningfully. Yet, actual classroom instruction regularly concentrates on procedural mechanics rather than conceptual mastery. This quantitative, quasi-experimental research assessed the individual and combined effectiveness of Contextual Teaching and Learning (CTL) and Discovery Learning on pupils' mathematical grasp. The study was modeled around a single-group interrupted time-series approach, involving 17 sixth-graders from UPTD SD Negeri Ra'as, Indonesia. Evaluation metrics were derived from a validated, reliable test and computed using simple and multiple linear regressions within the IBM SPSS Statistics 25 environment. The investigation revealed that CTL significantly altered students' understanding ($R^2 = 0.949, p < .001$), with Discovery Learning yielding a slightly higher magnitude of effect ($R^2 = 0.959, p < .001$). Cojointly, the two teaching methodologies explained 99.1% of the fluctuations in the participants' mathematical comprehension ($R^2 = 0.991, p < .001$). Ultimately, these insights imply that merging contextualized learning tasks with guided discovery serves as a highly effective pedagogical strategy to elevate conceptual math competencies at the primary level.

Keywords: Contextual teaching and learning; Discovery learning; Elementary mathematics education; Mathematical understanding.

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## INTRODUCTION

Elementary school students should strive to become proficient in mathematical understanding because it lays the foundation for other important skills, including reasoning, problem-solving, logical thinking, and connecting mathematical concepts to real-life scenarios (Hidayana & Lianingsih, 2025; Torres-Peña, Peña-González, Lara-Orozco, Ariza, & Vergara, 2025). Mathematics proficiency among Indonesian students is still below standard, according to several foreign evaluations (Setiawan, Muhtadi, & Hukom, 2022). The average math score of Indonesian students was 366 in the 2022 PISA, significantly lower than the average score of 472 for OECD students. Furthermore, while 69% of OECD students achieve the minimum level of proficiency (Level 2), only about 18% of Indonesian students do (Ulfa, Oktaviana, & Hasanah, 2024; Rizkianti, Asbari, Priambudi, & Asri, 2024).

From what can be seen, most students still struggle with mathematical understanding, mathematical reasoning, and applying what they have learned to real-world challenges.

This low achievement indicates that mathematics learning still tends to be oriented towards mastering procedures rather than conceptual understanding (Ncube, & Luneta, 2025). In practical learning, students are more directed to memorize formulas, follow examples of solutions given by the teacher, and then work on exercises that have a similar pattern (Siregar, Fauzan, Yerizon, & Syafriandi, 2025). This approach does help students solve routine problems, but it does not provide them with the opportunity to build a deeper understanding of the concepts being studied. Therefore, students often struggle, even after having studied the material, when faced with challenges that require interpretation, reasoning, or application of concepts in various contexts. Students' capacity to understand the significance of each idea used in problem-solving is as important as their ability to find the right solution in mathematics, under these conditions (Nilimaa, 2023).

Mathematical understanding is the ability to explain concepts, connect various mathematical representations, choose appropriate procedures, and use these ideas in various contexts to solve problems (Chen, 2025). Because this skill is directly proportional to how well students reason mathematically, it is a key indicator tested in a number of international exams. Therefore, it is crucial that mathematics instruction in elementary schools prioritizes the development of conceptual knowledge (Prediger, Dröse, Stahnke, & Ademmer, 2023). In addition to conveying information, teachers must be skilled at designing lessons that position students to construct their own knowledge through engagement in activities that are relevant to their lives and designed with their needs in mind.

This problem was also found in mathematics learning in grade VI of the UPTD SD Negeri Ra'as, Bangkalan Regency - East Java. Based on observations during the learning process, most students are still oriented towards finding the final answer without understanding the reasons for using concepts or solving procedures. Students tend to wait for teacher explanations, are less active in expressing ideas, and experience difficulties when asked to re-explain concepts they have learned using their own words. In addition, when challenged to answer questions in front of the class, some students appear nervous and have difficulty connecting fraction problems with real-world difficulties. This problem highlights the need to improve students' arithmetic literacy by implementing learning strategies that encourage active student participation in constructing ideas independently.

One learning model that is believed to be able to improve mathematical understanding is Contextual Teaching and Learning (CTL) (Mallika, 2024, Kusnirova, Scholtzova, & Kresila, 2026). CTL emphasizes the connection between learning materials and real experiences experienced by students so that abstract mathematical concepts become easier to understand (Ferede, Ayele, Mihrka, & Arara, 2026). Through contextual learning, students are encouraged to connect new knowledge with previous experiences, discuss, ask questions, reflect, and construct concepts based on situations they encounter in everyday life (Rumani, 2025). By engaging in this process, students are able to gain a deeper conceptual understanding, in contrast to learning approaches that are only informative (Ratnaningsih & Triwahyuni, 2025).

In addition to CTL, Discovery Learning is also considered effective in developing students' mathematical understanding (Vale & Barbosa, 2023). This model provides opportunities for students to discover concepts through the process of observing, gathering information, analyzing, testing hypotheses, and drawing conclusions independently with teacher guidance (Saptarini, Sukirman, & Santoso, 2022). Students' active involvement during the discovery process not only improves critical thinking and problem-solving skills but also helps students build deeper relationships between concepts (Saputri, Riyadi, & Matsuri, 2024). Thus, concepts learned through the discovery process tend to be easier to understand and remember than concepts learned through memorization.

Various studies have proven the effectiveness of both models in improving mathematics learning outcomes. Research by Dewi, Wiarta, & Ambara (2026) showed that the application of CTL has a significant impact on improving students' mathematical understanding. Similar results were also reported by Tamur, M., Jehadus, Nendi, Mandur, & Murni (2020), who found that contextual learning is more effective than direct learning in improving mathematical understanding. On the other hand, Kamaluddin & Widjajanti (2019) and Algebraic (2023) reported that Discovery Learning can improve understanding of mathematical concepts because it provides opportunities for students to actively discover concepts through a process of exploration and investigation.

However, most previous research has only evaluated the effectiveness of Contextual Teaching and Learning or Discovery Learning separately. Research analyzing the contribution of both models, either partially or simultaneously, to elementary school students' mathematical comprehension is still relatively limited. Yet, both models have complementary characteristics. CTL emphasizes meaningful learning through real-life contexts, while Discovery Learning focuses on the process of actively discovering concepts. This combination of characteristics has the potential to produce a more comprehensive learning experience in developing students' mathematical understanding.

Based on the description, the purpose of this study is to examine the relationship between elementary school students' arithmetic comprehension abilities with the partial and simultaneous use of Contextual Teaching and Learning and Discovery Learning. By using the same quasi-experimental design, this study analyzes the contribution of both learning models. This allows for a comprehensive evaluation of the effectiveness of each model and their combined influence on elementary school students' mathematical comprehension abilities.

## RESEARCH METHOD

This study uses a quantitative approach with a quasi-experimental design through a Single-Group Interrupted Time-Series Design. This design was chosen because it allows researchers to evaluate changes in students' mathematical understanding abilities after receiving two learning treatments sequentially without using a control group. All participants followed a series of learning using the CTL and Discovery Learning models, then mathematical understanding abilities were measured after each treatment so that the influence of each model and the contribution of both could be analyzed empirically.

The research was conducted at the grade VI of the UPTD SD Negeri Ra'as, Bangkalan Regency - East Java, involving 17 sixth-grade students as the research sample. The sampling technique used purposive sampling, namely the selection of samples based on the class teacher's consideration that all participants have relatively homogeneous learning characteristics and have followed the entire series of research treatments.

The research instrument was a descriptive test of mathematical understanding ability which was compiled based on indicators of mathematical understanding, including (1) re-explaining mathematical concepts, (2) classifying objects based on the properties of concepts, (3) applying concepts or algorithms appropriately in solving problems, and (4) connecting various mathematical representations. The instrument consisted of four descriptive questions which were first tested for validity and reliability before being used in the main research. The validity of the items was analyzed using Pearson Product Moment correlation, while the reliability of the instrument was calculated using Cronbach's Alpha coefficient.

Data collection was conducted through tests after each learning model was implemented. All student responses were assessed using a scoring guideline developed according to mathematical comprehension indicators, so that each score reflects the student's level of conceptual mastery. IBM SPSS Statistics 25 was used to analyze the data. To describe students' mathematical comprehension, we used descriptive analysis. To test the influence of CTL and Discovery Learning, we used simple linear regression. To test the contribution of both models simultaneously, we used multiple linear regression. Finally, for inferential analysis, we used logistic regression. Normality, heteroscedasticity, multicollinearity, and autocorrelation were all met by the regression model before hypothesis testing. This allows for a valid interpretation of the analysis results.

## RESULTS AND DISCUSSION

### Result

Before hypothesis testing was conducted, the mathematical comprehension ability test instrument was first tested for validity and reliability to ensure that the instrument was able to measure the construct being studied accurately and consistently. Validity testing was conducted on all test items using a significance value (Sig. 2-tailed), while the instrument's reliability was analyzed using the Cronbach's Alpha coefficient.

Table 1. Results of Instrument Validity and Reliability Tests

| Learning model | Validity of Question Items | Reliability (Cronbach's Alpha) | Information |
|---|---|---|---|
| Contextual Teaching and Learning (CTL) | All items are valid (Sig. = 0.000–0.048) | 0.680 | Reliable |
| Discovery Learning (DL) | All items are valid (Sig. = 0.000–0.007) | 0.712 | Reliable |

Based on Table 1, all items on the mathematical comprehension ability instrument have a significance value of less than 0.05 and are therefore declared valid. In addition, the Cronbach's Alpha value for both instruments is above the minimum limit of 0.60, indicating that the instrument has good internal consistency. Thus, the instrument is suitable for use in measuring students' mathematical comprehension ability at the data collection stage.

Before conducting a regression analysis, basic regression assumptions are tested, including tests for normality, heteroscedasticity, autocorrelation, and multicollinearity. This testing aims to ensure that the regression model meets statistical requirements so that the analysis results can be interpreted validly.

Table 2. Summary of Regression Assumption Test Results

| Test Type | Mark | Criteria | Decision |
|---|---|---|---|
| Normality | 0.200 | > 0.05 | Normally distributed |
| CTL heteroscedasticity | 0.731 | > 0.05 | There is no heteroscedasticity |
| DL heteroscedasticity | 0.957 | > 0.05 | There is no heteroscedasticity |
| Autocorrelation | 0.308 | > 0.05 | No autocorrelation occurs |
| Tolerance | 0.175 | > 0.10 | Meet the assumptions |
| VIF | 5,705 | < 10 | There is no multicollinearity |

The test results indicate that all regression assumptions have been met. The significance value of the normality test of 0.200 indicates that the residuals are normally distributed. Similarly, the heteroscedasticity test produces a significance value above 0.05 for both independent variables, so no symptoms of heteroscedasticity are found. The results of the autocorrelation test also indicate no residual correlation, while the Tolerance and Variance Inflation Factor (VIF) values indicate that there is no multicollinearity between predictors. Thus, the regression model is declared to meet all analysis requirements.

Simple linear regression analysis was used to determine the magnitude of the influence of the CTL model on students' mathematical understanding abilities.

Table 3. Results of Simple Linear Regression Analysis of the CTL Model

| Variables | B | β | t | Sig. | $R^2$ |
|---|---|---|---|---|---|
| Constant | -3,233 | - | -0.606 | 0.554 | |
| CTL | 8,390 | 0.974 | 16,689 | 0,000 | 0.949 |

The results of the analysis show that the Contextual Teaching and Learning model has a significant effect on students' mathematical understanding abilities ($\beta = 0.974$; $p < 0.001$). The coefficient of determination ($R^2 = 0.949$) shows that 94.9% of the variation in mathematical understanding abilities can be explained by the application of the CTL model, while the rest is influenced by other factors outside the research model. The positive regression coefficient indicates that the more optimal the application of CTL, the higher the students' mathematical understanding abilities.

Furthermore, a simple linear regression analysis was conducted to determine the effect of the Discovery Learning model on students' mathematical understanding abilities.

Table 4. Results of Simple Linear Regression Analysis of the Discovery Learning Model

| Variables | B | β | t | Sig. | $R^2$ |
|---|---|---|---|---|---|
| Constant | 10,342 | - | 2,564 | 0.022 | |

| | | | | | |
|---|---|---|---|---|---|
| Discovery Learning | 7,557 | 0.979 | 18,725 | 0,000 | 0.959 |

Based on Table 4, the Discovery Learning model has a significant influence on students’ mathematical understanding ability ($\beta = 0.979$; $p < 0.001$). The $R^2$ value of 0.959 indicates that the Discovery Learning model is able to explain 95.9% of the variation in students’ mathematical understanding ability. The positive regression coefficient value indicates that an increase in the quality of Discovery Learning implementation is followed by an increase in students’ mathematical understanding ability.

To determine the contribution of the two learning models together to students' mathematical understanding abilities, multiple linear regression analysis was carried out.

Table 5. Results of Multiple Linear Regression Analysis

| Variables | B | β | t | Sig. |
|---|---|---|---|---|
| Constant | 0.345 | - | 0.143 | 0.888 |
| CTL | 3,645 | 0.389 | 7,066 | 0,000 |
| Discovery Learning | 4,892 | 0.634 | 11,518 | 0,000 |

To determine the simultaneous influence of Contextual Teaching and Learning (CTL) and Discovery Learning (DL) on students' mathematical comprehension, a multiple linear regression analysis was conducted. This analysis aims to identify the contribution of each independent variable while evaluating the ability of the regression model to explain variations in students' mathematical comprehension.

The results of the analysis include the regression coefficient of each variable, the coefficient of determination ($R^2$), and the overall model significance test, which are presented in Table 6.

Table 6.Summary of Multiple Linear Regression Analysis Results

| Model Summary | Mark |
|---|---|
| R | 0.959 |
| $R^2$ | 0.991 |
| F | 772,181 |
| Sig. | 0,000 |

The results of multiple linear regression analysis show that the model built has a very good level of significance ($F = 772.181$; $p < 0.001$). The coefficient of determination value of 0.991 indicates that the simultaneous application of Contextual Teaching and Learning and Discovery Learning is able to explain 99.1% of the variation in students' mathematical understanding abilities. In addition, both independent variables provide a significant contribution to the regression model.

The beta coefficient value shows that Discovery Learning has a relatively greater contribution ($\beta = 0.634$) compared to Contextual Teaching and Learning ($\beta = 0.389$) in explaining students' mathematical understanding abilities.

Table 7. Summary of Hypothesis Testing Results

| Hypothesis | Analysis Results | Decision |
|---|---|---|
| H1 | CTL has an effect on students' mathematical understanding abilities ($\beta = 0.974$; $p < 0.001$) | Accepted |

| | | |
|---|---|---|
| H2 | Discovery Learning has an effect on students' mathematical understanding abilities ($\beta = 0.979$; $p < 0.001$) | Accepted |
| H3 | CTL and Discovery Learning simultaneously influence students' mathematical understanding abilities ($R^2 = 0.991$; $F = 772.181$; $p < 0.001$) | Accepted |

Overall, the research results show that both Contextual Teaching and Learning and Discovery Learning have a positive and significant influence on elementary school students' mathematical comprehension abilities. In addition to their partial influence, both learning models also show a very strong contribution when applied simultaneously, so that both have the potential to be alternative effective learning strategies in improving students' mathematical comprehension.

**Discussion**

According to research findings, students' mathematical understanding is positively and significantly influenced by the implementation of CTL. Based on these results, teaching students how to apply mathematical ideas in real-world contexts produces better results than teaching them how to solve problems in isolation. Learning mathematics is much more than simply memorizing formulas; it is also about the ability to apply what has been learned to new contexts, justify the reasoning behind a technique, and elaborate on the significance of their solutions. Consequently, students engage in a deeper knowledge-building process when they are given the opportunity to acquire ideas in situations close to their everyday lives.

Theoretically, this finding is in line with the theory of constructivism which is the main foundation of Contextual Teaching and Learning. Constructivism theory views that knowledge cannot be transferred directly from teachers to students, but must be built through learning experiences that involve active thinking processes (Nithideechaiwarachok & Chano, 2024). In this study, CTL learning allows students to connect fraction material with situations they encounter in everyday life so that concepts that were originally abstract become more concrete. The activities of observing, discussing, asking questions, and reflecting on learning experiences provide opportunities for students to develop relationships between concepts so that mathematical understanding does not stop at the procedural level, but develops towards conceptual understanding.

The results of this study also show that real-world contexts act as a bridge between students' learning experiences and the mathematical concepts they learn. When students are able to connect previous experiences with new information, the processes of conceptual assimilation and accommodation are more effective. This allows students to understand the rationale for using a concept in problem-solving, rather than simply understanding the procedure. Thus, CTL improves students' mathematical thinking skills because they learn in a more meaningful way, which in turn improves learning outcomes.

The findings of this study reinforce the findings of Jannah, Tobroni, & Dewi (2024), who reported that the application of CTL contributes to improving students' mathematical understanding. These findings are also consistent with the findings of Woods & Copur-Gencturk (2024), who showed that contextual learning is more effective than direct learning in developing understanding of mathematical concepts. However, this study provides a broader perspective because it not only evaluates the effectiveness of CTL separately but also analyzes its contribution alongside other learning models within the same research design.

In addition to Contextual Teaching and Learning, this study also shows that mathematical understanding is improved by using Discovery Learning. This study shows that students can gain a more comprehensive understanding through the process of exploring concepts independently rather than relying solely on teacher-led explanations. During the learning process, students are encouraged to observe problems, gather information, identify patterns, test hypotheses, and draw conclusions based on the results of their exploration. This series of activities provides opportunities for students to build concepts through scientific thinking processes so that the knowledge gained becomes more meaningful and lasts longer.

Discovery Learning provides a space for students to develop critical thinking and mathematical reasoning skills simultaneously (Varveris, Saltas, & Tsiantos, 2023). When students discover the concepts they are learning for themselves, they not only understand the final result but also the logical process behind the formation of the concept. This condition strengthens students' ability to connect various mathematical representations, choose the right problem-solving strategy, and re-evaluate the answers obtained. Therefore, discovery-based learning contributes to the formation of a more comprehensive mathematical understanding compared to learning that is only oriented towards the delivery of information.

The findings of this study support Bruner's discovery learning theory, which emphasizes the importance of active student involvement in constructing knowledge through exploration and discovery (Ozdem-Yilmaz & Bilican, 2025). In the context of elementary school mathematics learning, this involvement enables students to develop curiosity, improve analytical thinking skills, and build stronger connections between the mathematical concepts they learn (Vasuki, Celestin, & Kumar, 2016). As a result, students are not only able to solve routine problems but are also better prepared to face problems that require reasoning and the application of concepts in new situations.

The results of this study are in line with the research of Sari, Gistituati, & Syarifuddin (2019) found that Discovery Learning is more effective than conventional learning in improving mathematical understanding of elementary school students. The effect of guided discovery learning method toward students' ability in understanding math concept. This finding also strengthens the research of Kristiyajati & Wijaya (2019). who showed that Discovery Learning is able to improve conceptual understanding through exploratory activities that encourage students to discover the relationship between mathematical concepts themselves. Thus, Discovery Learning can be seen as one of the relevant learning models for developing mathematical understanding skills at the elementary school level (Kurino, Herman, Turmudi, & Azhari, 2024).

According to research, students' mathematical understanding is significantly better when CTL and Discovery Learning are used together. Based on these findings, it is clear that the two learning models are not direct substitutes for each other, but rather strengthen mathematical understanding in different ways. CTL plays a role in building meaning by connecting concepts to students' real-life experiences, while Discovery Learning strengthens the process of concept formation through exploration and discovery activities. The integration of these two approaches creates a learning environment that allows students to understand mathematical concepts contextually while constructing knowledge through active learning experiences.

The synergy of these two learning models provides a more comprehensive learning experience than using either model alone. When learning begins in a context close to students' lives, motivation and engagement increase because students are able to see the relevance of the material being studied. Furthermore, through the discovery process, students have the opportunity to explore various alternative solutions, test their strategies, and reflect on their results. By combining the two, students not only gain a deeper understanding of the material but also hone their analytical, reasoning, communication, and problem-solving skills in mathematics (Paputungan, Mamu, & Katili, 2022; Anugraheni, Oetomo, & Santosa, 2018).

From a pedagogical perspective, our research findings suggest that teaching mathematics to elementary school students requires strategies that focus on content presentation and offer opportunities for active knowledge construction (Dairo, Okonkwo, & Orakwe, 2024). Contextual learning without exploration can lead students to only understand the relationship between concepts and real-life situations, while discovery-based learning without context can cause students to have difficulty connecting concepts to everyday experiences. Therefore, integrating CTL and Discovery Learning is a more comprehensive alternative learning strategy for improving students' mathematical understanding.

Previous research has largely focused on comparing the two models separately, rather than demonstrating how they work together to improve students' mathematical knowledge. The results of this study suggest that elementary school teachers should consider using alternative learning strategies to help their students develop deeper mathematical understanding: strategies that combine active discovery processes with contextual experiences.

Based on the findings of this study, placing children at the center of their own learning is key to improving their mathematical knowledge in elementary school. Educators must go beyond simply outlining ideas and providing students with practice with procedures; they must create lessons that help students make connections between mathematics and the real world and find answers to their questions through guided investigations. Therefore, if students are looking for a way to learn mathematics that is engaging and relevant, with an emphasis on developing higher-order thinking skills, CTL and Discovery Learning may be good options.

## CONCLUSION

This study proves that Contextual Teaching and Learning (CTL) and Discovery Learning have a positive and significant influence on elementary school students' mathematical understanding abilities, both partially and simultaneously. Both learning models are able to create a more meaningful learning experience through the active involvement of students in connecting mathematical concepts with real-life contexts and discovering concepts independently. The research findings also show that the application of both models together provides a more optimal contribution than their separate applications.

The findings of this study reinforce the idea that improving students' conceptual understanding of mathematics can be achieved through the integration of contextual experiences and discovery activities into the learning process. Therefore, to promote more engaging and purposeful mathematics education that focuses on improving students' critical thinking skills, it is recommended that elementary school educators make optimal use of both learning models.

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