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EFFECTS OF CONTEXTUAL TEACHING AND LEARNING WITH POP-UP BOOKS ON ELEMENTARY STUDENTS' MATHEMATICAL CONCEPT UNDERSTANDING

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ABSTRACT
This study is motivated by the low ability of students to understand mathematical concepts. One of the internal factors contributing to students' low mathematical conceptual understanding is their negative perception of mathematics as a subject. Mathematics is often perceived as difficult, uninteresting, and monotonous, leading students to believe that the learning materials are challenging to comprehend. Such perceptions may reduce students' motivation and engagement in the learning process, which ultimately results in lower levels of mathematical conceptual understanding and overall academic achievement. Efforts that can be conducted to overcome this problem are to hold interactive learning and the use of innovative learning models and media. The learning models which were used were the Contextual Teaching and Learning model assisted by pop-up book media. The aims of this study is to determine the effect of the Contextual Teaching and Learning model assisted by pop-up book media on students' mathematical concept understanding abilities; besides, to determine the differences in the improvement of mathematical concept understanding abilities between students who implement the Contextual Teaching and Learning model and Problem-Based Learning. This study used a quasi-experimental method with a Non-equivalent Control Group Design. The findings of the study indicate that the Contextual Teaching and Learning (CTL) model has a significant positive effect on students' mathematical conceptual understanding, as evidenced by the improvement in elementary school students' learning outcomes.
Keywords: contextual teaching and learning; mathematical concepts; pop-up book.

ABSTRAK
Penelitian ini dilatarbelakangi oleh rendahnya kemampuan pemahaman konsep matematis siswa. Salah satu faktor internal yang mempengaruhi rendahnya kemampuan pemahaman konsep matematis siswa adalah pikiran negatif siswa terhadap pelajaran matematika itu sendiri. Pelajaran matematika masih dianggap mata pelajaran yang sulit dan menakutkan karena tidak menarik, membosankan dan sulit dipahami oleh peserta didik yang menyebabkan rendahnya hasil belajar siswa. Salah satu upaya yang dapat dilakukan untuk mengatasi permasalahan tersebut adalah mengelar pembelajaran yang interaktif dan penggunaan model serta media pembelajaran yang inovatif. Salah satu model pembelajaran yang dapat digunakan adalah model Contextual Teaching and Learning berbantuan media pop-up book. Penelitian ini bertujuan untuk mengetahui pengaruh model pembelajaran Contextual Teaching and Laerning berbantuan media pop-up book terhadap kemampuan pemahaman konsep matematis siswa serta mengetahui perbedaan peningkatan kemampuan pemahaman konsep matematis antara siswa yang belajar menggunakan model Contextual Teaching and Laerning dan Problem Based Learning. Penelitian ini menggunakan metode kuasi eksperimen dengan desain Non-equivalent Control Group Design. Hasil penelitian menunjukkan bahwa model pembelajaran Contextual Teaching and Learning memiliki pengaruh yang signifikan terhadap kemampuan pemahaman konsep matematis siswa dilihat dari peningkatan hasil belajar siswa sekolah dasar.
Kata kunci*: contextual teaching and learning; pemahaman konsep: pop-up book*

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Introduction

Mathematics is a science that has a vital role in the development of technology and science, as well as the development of logical, systematic, analytical, critical, and creative thinking (Meidianti et al., 2022). Furthermore, it is considered an international language that has a single meaning that makes it understandable to all groups, regardless of nationality, ethnicity, or religion (Mytra et al., 2023). The independent mathematics curriculum aims to equip students with the ability in order to understand mathematical concepts, such as logical and systematic thinking, explaining relationships between concepts, and applying mathematical concepts in daily life. In basic education, mathematics also plays a crucial role in training students to relate abstract concepts to real-world situations and in making learning more meaningful. Therefore, mathematics is a compulsory subject taught at every level of education from kindergarten to university.

One of the fundamental skills students must possess related to mathematics learning is the ability to understand mathematical concepts. Conceptual understanding is the ability to restate what has been taught (Rohmah et al., 2024). In mathematics, conceptual understanding refers to students' ability to comprehend, explain, and reapply mathematical concepts in order to solve various mathematical and contextual problems. Furthermore, conceptual understanding aims to help students understand, recognize, and re-express the material presented effectively, rather than simply memorizing formulas or sentences provided by the teacher or reading materials (Nurfajriyanti & Pradipta, 2021). Ideally, students should develop this conceptual understanding of mathematics starting in elementary school so that they can understand the mathematical material they will encounter at higher levels of education (Maryati, 2023). Conceptual understanding is a fundamental ability that students must possess to classify objects, explain concepts in their own words, and apply concepts to solve mathematical problems (Khoiruddin et al., 2024). Therefore, mathematics material in elementary schools needs to be designed appropriately in order to help students build and develop an optimal understanding of mathematical concepts.

By having a good conceptual understanding, students are not only able to memorize formulas, but also understand the meaning of each mathematical concept learned and they are able to implement it to various situations and problems they encounter. According to Heruman, there are seven indicators of conceptual understanding, including: (1) restating a concept, (2) classifying objects according to certain properties based on the concept, (3) providing examples and non-examples of a concept, (4) presenting concepts in various forms of mathematical representation, (5) developing necessary or sufficient conditions for a concept, (6) using, utilizing, and selecting certain procedures or operations, and (7) applying concepts or algorithms in problem solving (Rohmah et al., 2024). Based on these seven indicators, mathematical conceptual understanding can be viewed as a comprehensive ability that encompasses understanding, classifying, representing,

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and applying concepts in problem-solving situations. Therefore, mastery of each indicator is essential to support students' success in mathematics learning.

However, in reality, students' understanding of mathematical concepts is still relatively low, where students are unable to fully grasp the concept in problem-solving (Audina et al., 2023). Various studies have shown that students in Indonesia continue to experience difficulties in achieving an adequate level of mathematical conceptual understanding (Maulida & Ghufron, 2025). The low level of students' mathematical conceptual understanding may be attributed to internal factors, such as low learning motivation, mathematics anxiety, and the tendency to memorize formulas without developing a deeper conceptual understanding. In addition, external factors also contribute to students' low conceptual understanding, including teacher-centered instructional methods that provide limited opportunities for active student participation, the lack of innovative instructional media and learning approaches, an unsupportive classroom environment, limited educational facilities, novice teachers who are less adaptive to students' cognitive development, and the limited involvement of parents with lower educational backgrounds in supporting learning at home (Fatimah, 2025; Mahardiyanti, 2024; Maysaroh et al., 2021; Utami, 2025). Assessments conducted by the Programme for International Students (PISA) also show similar results, where students' mathematical conceptual understanding ability is still in the low category, one of which is caused by students being accustomed to procedural problems without understanding the basic concepts (Mmpuni & Syaichudin, 2021). In addition, mathematics is generally considered a difficult and intimidating subject since it is uninteresting, boring, and difficult for students to understand (Indofah & Hasanudin, 2023). This is because mathematics is often believed as abstract learning with its hierarchical concepts and principles (Kusnadi et al., 2021). Therefore, students' understanding of mathematical concepts at the elementary level requires greater attention as an effort to improve the quality of education. Reforms or solutions are needed to address this issue.

One learning model that is considered suitable for helping improve students' understanding of mathematical concepts is the Contextual Teaching and Learning (CTL) model. The CTL model itself is a learning strategy that emphasizes student involvement in fully discovering the material to be studied and connecting it to real-life situations so that students can apply it in their daily lives and learning becomes more meaningful (Nababan, 2023). The Contextual Teaching and Learning (CTL) model is closely related to students' conceptual understanding because it connects learning materials with real-life situations, making concepts more meaningful and easier to understand. Through active learning experiences, students construct their own knowledge, develop a deeper understanding of concepts, and apply them in various contexts. Therefore, the implementation of the CTL model can improve students' mathematical conceptual understanding. The Contextual Teaching and Learning (CTL) approach has several key characteristics, including learning based on real-life environments, functional learning, direct experiential learning, collaborative learning, active student participation, a conducive classroom atmosphere, and the development of meaningful social relationships (Kholid, 2023). The Contextual Teaching and Learning (CTL) model consists of seven major components that facilitate meaningful learning by connecting instructional

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activities with students' everyday experiences. Its core principle is constructivism, which emphasizes that knowledge should be actively constructed by students through interaction with their environment (Muzaini & Fadhilah, 2022). In addition to using an appropriate learning model, interactive learning media which can bridge the gap is also needed to help students more easily understand mathematical concepts and the material presented. One learning media which can be used to improve students' ability to understand mathematical concepts is the pop-up book. Since pop-ups book can visualize mathematical material that is considered abstract, it make easier for students to understand the material presented. Therefore, the use of the Contextual Teaching and Learning (CTL) model with the help of pop-up book learning media in the learning process can help students understand concepts in a more concrete and meaningful way. The purpose of this study is to determine the effect of the Contextual Teaching and Learning (CTL) model assisted by pop-up book media on improving students' mathematical conceptual understanding. The CTL model was selected because it connects learning materials with real-life situations, allowing students to actively construct their own understanding through meaningful learning experiences. In addition, the use of pop-up book media helps visualize mathematical concepts, making the learning process more engaging, concrete, and easier for students to understand. Based on the theoretical framework, the hypothesis of this study is that the implementation of the Contextual Teaching and Learning (CTL) model assisted by pop-up book media has a positive and significant effect on improving elementary school students' mathematical conceptual understanding.

Research Methods

This study used a quasi-experimental method with a Non-Equivalent Control Group Design. According to Cook (as cited in Abraham & Supriyati, 2022), a quasi-experimental design is an experimental approach that involves the implementation of a treatment, the measurement of its effects, and the use of experimental units, but does not employ random assignment to create comparison groups for drawing causal inferences regarding the effects of the treatment. Thus, the Non-Equivalent Control Group Design is capable of providing an adequate representation of the causal relationship between the independent and dependent variables by comparing the learning outcomes of the experimental and control groups. Although this design does not employ random assignment, it still offers sufficient validity to evaluate the effectiveness of an educational intervention. The use of the Non-Equivalent Control Group Design in this study aims to obtain more objective, systematic, and comprehensive evidence regarding the effect of the Contextual Teaching and Learning (CTL) model on elementary school students' mathematical conceptual understanding. By administering a pre-test prior to the intervention and a post-test following the intervention to both groups, the researcher was able to identify students' initial levels of conceptual understanding and measure the changes that occurred after the implementation of the learning process. Comparing the results of the experimental and control groups provides a sound basis for evaluating the effectiveness of the CTL model relative to the instructional approach used in the control group. Furthermore, this design was selected because it is well suited to educational research contexts, where class assignments are typically

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predetermined by the school, making random assignment of participants impractical. Therefore, the Non-Equivalent Control Group Design is considered an appropriate research design, as it allows the study to be conducted in a natural classroom setting without disrupting the ongoing teaching and learning process while producing findings that are both valid and scientifically reliable. The following is a Quasi-Experimental Design with a Non-Equivalent Control Group Design described by Sugiono (2022) in Table 1.

Table 1 Research Method

Experimental Group	P1 X P2
Control Group	P1 X P2

(Sugiono, 2022)

The study involved two groups: the experimental group that received learning using the Contextual Teaching and Learning (CTL) model assisted by pop-up book media and the control group that received learning using the Problem-Based Learning (PBL) model assisted by pop-up book media. The population of this study comprised all fifth-grade students enrolled in elementary schools in Purwakarta Regency. The selection of this population was based on accreditation data indicating that, out of a total of 419 elementary schools in Purwakarta, 191 schools were accredited A and 212 schools were accredited B. This distribution reflects that the majority of elementary schools in the region meet national educational quality standards, making them appropriate for inclusion in the research population.

The sample consisted of two fifth-grade classes, namely Class VA and Class VB. The sample was selected using a purposive sampling technique, in which participants were chosen based on the objectives of the study. In addition, interviews were conducted with the homeroom teachers of both fifth-grade classes. The interview results indicated that the two classes had relatively similar academic achievement and homogeneous learning abilities, making them suitable for comparison and consistent with the research objectives. Furthermore, Class VB was assigned as the experimental group because its students demonstrated characteristics that were well suited to the implementation of the Contextual Teaching and Learning (CTL) model, particularly their active engagement in relating learning materials to real-life situations. In contrast, Class VA was assigned as the control group because its students tended to be more active in problem-solving activities and classroom discussions, making the Problem-Based Learning (PBL) model an appropriate comparison. The experimental group consisted of 27 students, including 15 boys and 12 girls, while the control group also consisted of 27 students, comprising 13 boys and 14 girls. The pop-up book module based on Realistic Mathematics Education (RME) has been proven to possess very high levels of feasibility and practicality, making it suitable for use as a mathematics learning medium (Dayani et al., 2021).

The research instrument was a mathematical concept understanding ability test, which was conducted through instrument quality testing, including validity, reliability, difficulty level, and discriminating power using the Anates program. The research instrument consisted of a pre-test and a post-test. The pre-test was administered to collect baseline data in the form of students' scores to assess their

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mathematical conceptual understanding before the implementation of the instructional treatment. Subsequently, the post-test was conducted to measure students' mathematical conceptual understanding after the treatment had been implemented. The comparison between the pre-test and post-test results was used to evaluate the effectiveness of the instructional intervention in improving students' mathematical conceptual understanding. Furthermore, the test was compiled based on seven indicators of mathematical concept understanding ability. The research data were analyzed by using the N-gain test in order to determine the increase in students' mathematical concept understanding ability, independent samples t-test to test the difference in improvement between the experimental group and the control group, and coefficient of determination analysis to determine the magnitude of the influence of the learning model on students' mathematical concept understanding ability.

Results and Discussion

In this study, the data obtained were analyzed by using descriptive statistics in order to determine the improvement in students' mathematical conceptual understanding based on the N-Gain score. Furthermore, an independent samples t-test was conducted to examine the difference in improvement between the experimental and control classes. The coefficient of determination test was used to determine the effect of the Contextual Teaching and Learning (CTL) model on students' mathematical conceptual understanding.

The results show that the implementation of the Contextual Teaching and Learning (CTL) model, supported by Pop-up Book media, have a positive effect on improving elementary school students' mathematical conceptual understanding in Table 2.

Table 2 Descriptive Analysis

Group	Test Type	Score		Mean ($\bar{x}$)	Standard deviation	N-Gain score	Criteria
		Min	Max				
Experiment	Pre-test	30	50	38,33	5,851	0,70	High
	Post-test	65	98	82,44	7,688		
Control	Pte-test	30	55	40,70	6,275	0,50	Moderate
	Post-test	53	88	71,67	8,110		

Based on Table 2, shows that the implementation of the learning model has a positive effect on student learning outcomes. It is proved by the increase in the average pre-test score in the experimental group by 38.33, to 82.44 in the post-test. Meanwhile, in the control group there is an increase where the average pre-test score of 40.70 increases to 71.67 in the post-test. It shows that the implementation of the learning model has a positive effect on student learning outcomes. However, the experimental group, which uses the CTL model assisted by Pop-up Book media, shows a better increase in learning outcomes. This is proven by the difference in the average post-test of the experimental group reaching 82.44, while the control group

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obtained an average of 71.67, which indicates that learning using the CTL model assisted by Pop-up Book media is able to provide a more effective learning experience than learning in the control group. The effectiveness of learning is also shown through the N-gain learning results, where the experimental group obtained an N-Gain result of 0.7039, which is included in the high category. Meanwhile, the control group achieved an N-Gain score of 0.5062, which is categorized as moderate. Although both groups experienced improvement, the high N-Gain score in the experimental class indicates that CTL learning is able to optimally improve conceptual understanding. This is because CTL itself is a learning concept that helps teachers connect the learning material being taught to real-world situations for students, as well as helping connect students' existing knowledge with its application in daily life (Hasudungan, 2022). Based on Piaget's theory of cognitive development, children at an early age have limited capacity to understand abstract concepts. Therefore, the learning process should be centered on concrete experiences that enable students to interact directly with their surrounding environment (Ilham, 2022). Through this approach, students develop knowledge and skills that can be applied flexibly to solve various types of problems (Nur & Masita, 2022). Furthermore, CTL enables students to relate the knowledge they acquire to their daily lives, thereby making learning more meaningful (Syarifah & Misbah, 2023). In addition, CTL employs authentic assessment to evaluate students' learning processes and outcomes in real and meaningful contexts (Tarigan, 2024). Pop-up books can enhance students' creativity and make learning more engaging through two- and three-dimensional visualizations (Vahlia et al., 2025). Furthermore, the Pop-up Book learning media, a concrete learning medium, can be used as a tool to facilitate student understanding of the knowledge presented.

In addition, an independent samples t-test is conducted to determine the difference in improvement between the experimental and control groups, and a coefficient of determination test to determine the effect of the Contextual Teaching and Learning (CTL) model on students' mathematical concept understanding in Table 3.

Table 3 Independent Sample t-Test Results of Pre-test and Post-test of Experimental Group and Control Group

Data	Significance Level	p-value Sig.(2-tailed)	Description
Pre-test of the experimental and control groups	Sig. > 0,05	0,157	There is no difference
Post-test of the experimental and control groups	Sig. < 0,05	< 0,001	There is a difference

Based on the results of the independent-samples t-test on the pre-test scores of the experimental group and the control group, a significance value of 0.157 is obtained, which is higher than the significance level of 0.05, so H0 can be accepted. Thus, it can be concluded that there is no significant difference between the initial ability of students' mathematical concept understanding in the experimental group and the control group, or is in a relatively similar initial condition. Furthermore, the

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independent sample t-test on the post-test scores of the experimental group and the control group obtained the result that the p-value (sig. 2-way) post-test in the experimental group and the control group is <0.001 or less than 0.05, which means that H0 for both classes is rejected. Therefore, it can be concluded that there is a difference in the average score of students' conceptual understanding abilities in the pre-test and post-test between the experimental group and the control group. However, the escalation of achievement in the experimental group shows a significantly greater intensity than the control group with an average difference of 10.778 points. It indicates that the experimental group using the CTL learning model achieves higher post-test scores than the control class using the Problem-Based Learning model, despite using the same media, namely Pop-up Books. Furthermore, the coefficient of determination test was conducted to determine the extent of the effect of the Contextual Teaching and Learning (CTL) model assisted by pop-up book media on students' mathematical conceptual understanding. This test aims to measure the contribution of the independent variable to the dependent variable in this study. The results of the coefficient of determination test are presented in Table 4.

Table 4 below.Table 4 Results of the Determination Coefficient Test

	R	**Adjusted R Square**	***R Square***	***Std***
Contextual Teaching and Learning Model assisted by Pop-up Book Media	0,748	0,542	0,560	5,202

(Source: Research, 2026)

The results of the determination coefficient test obtained an R value of 0.748, which indicates that the relationship between the variables in this study is considered in the strong category. The R Square value of 0.560 indicates that the application of the Contextual Teaching and Learning model assisted by Pop-up Book media has an effect of 56% on students' mathematical concept understanding abilities. Meanwhile, the remaining 44% is affected by other factors not examined in this study. In addition, the R Square value of 0.542 indicates that the implementation of the Contextual Teaching and Learning model assisted by Pop-up Book media is able to explain changes in students' mathematical concept understanding abilities by 54.2%. The findings of this study are consistent with Piaget's constructivist theory, which states that students actively construct their knowledge through meaningful learning experiences. In the implementation of the Contextual Teaching and Learning (CTL) model, students are given opportunities to relate mathematical concepts to real-life situations, allowing conceptual understanding to develop through the processes of assimilation and accommodation. Furthermore, Vygotsky's social constructivist theory explains that interactions between students, teachers, and peers through questioning, discussion, and collaborative learning help students develop a deeper understanding of mathematical concepts. These findings are also supported by Bruner's learning theory, which emphasizes that students understand concepts more effectively when they are given opportunities to discover them through concrete learning experiences. The use of pop-up book media further

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strengthens this learning process by providing engaging and concrete visual representations that make mathematical concepts easier for students to understand. Furthermore, the std value, Error of the Estimate of 5.202 indicates the level of error of the regression model in estimating students' mathematical concept understanding abilities. Therefore, it can be concluded that the implementation of the Contextual Teaching and Learning (CTL) model assisted by pop-up book media is more effective in improving students' mathematical concept understanding abilities compared to the Problem Based Learning (PBL) model which uses the same media. In addition, the application of the CTL model has a positive influence on students' ability to understand mathematical concepts.

Conclusion and Suggestion

This study shows that the implementation of the CTL model assisted by Pop-up Book media is effective in improving the ability to understand mathematical concepts of elementary school students, as shown by the N-Gain results. The experimental group, which received instruction through the Contextual Teaching and Learning (CTL) model supported by pop-up book media, demonstrated a greater improvement in mathematical conceptual understanding than the control group, which was taught using the Problem-Based Learning (PBL) model. These findings indicate that the integration of the CTL model with pop-up book media was more effective in enhancing students' mathematical conceptual understanding than the instructional approach implemented in the control group.

In addition, the results of the coefficient of determination test indicate that the CTL model assisted by pop-up book media has a positive effect on students' ability to understand mathematical concepts. Thus, the CTL model, assisted by pop-up book media, can be used as an alternative for mathematics learning to improve elementary school students' understanding of mathematical concepts. Through the implementation of the Contextual Teaching and Learning (CTL) model, students became more actively engaged in observing, asking questions, discovering concepts, participating in discussions, and relating mathematical concepts to real-life situations. Furthermore, the use of pop-up book media facilitated students' understanding of the characteristics of plane figures by presenting the material in a more concrete, interactive, and engaging manner. As a result, students were able to construct their conceptual understanding more effectively through meaningful learning experiences. Further researchers are expected to develop this study on materials, educational levels, or other variables by involving a wider sample so that more comprehensive results are obtained.

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