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The Influence of the Concrete Pictorial Abstract Approach on Students' Conceptual Understanding

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ABSTRACT

The low conceptual understanding of mathematics in elementary schools is often caused by learning practices that ignore the cognitive phase of students, which is the background of this research. This study aims to test whether or not there is and how much influence the concrete pictorial abstract approach has on students' conceptual understanding of plane geometry material. A quantitative approach with a quasi-experimental research type was used in this study. The sampling technique used was saturated sampling which is included in nonprobability sampling. The data collection technique was carried out through written tests in the form of pretests and posttests. The data analysis technique used was the normality and homogeneity test as prerequisite tests. The Independent Sample T-test and Cohen's d test were used for hypothesis testing. The results of the study showed that (1) There is an influence of the concrete pictorial abstract approach on students' conceptual understanding of plane geometry material, as shown in the results of the Independent Sample T-test with a Sig. value of 0.001 ($\leq$ 0.05), so that Ha1 is accepted and Ho1 is rejected. (2) There is a large influence of the concrete pictorial abstract approach on students' conceptual understanding of the material on flat shapes, as shown by the results of the Cohen's d test with a d value of 1.31 ($\geq$ 0.8), so that Ha2 is accepted and Ho2 is rejected. The results of the study confirm that the implementation of concrete pictorial abstracts increases students' conceptual understanding statistically and has practical significance.

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1. INTRODUCTION

Teachers need to develop and create learning approaches to foster students' self-confidence, passion, and enthusiasm for learning. A learning approach is defined as a collection of methods or approaches used by educators to implement learning. A learning approach can also be defined as a perspective on the learning process, which takes the form of an initial plan for determining the implementation of the learning process. [1]. There are two types of approaches, namely teacher-centered approaches and student-centered approaches.

Conceptual understanding is very important and is a standard ability that elementary school students must have, or can be said to be a benchmark for the success of learning mathematics. [2]. The main goal of conceptual understanding is for students to gain a deeper understanding of mathematical concepts. Without conceptual understanding, students will not be able to solve problems effectively. [3]. Teachers always strive to improve conceptual understanding. The most common way for teachers to improve students' conceptual understanding is by adapting approaches, models, and methods to their learning needs. [4].

Mathematics learning in elementary schools ideally uses an approach that involves or connects concrete objects around us into something abstract to provide conceptual understanding for students, or what is usually called the use of manipulatives [5]. The needs of elementary school aged children or 7-11 years are in the concrete operational phase, where their learning stage is to be able to use logic using concrete objects.

[6]. The use of concrete objects in elementary school mathematics learning is necessary to help students logically align with their developmental stage, namely the concrete operational phase. Teachers should teach from the concrete to the abstract, or from the easy to the difficult, to provide students with a deeper conceptual understanding. [7].

To date, we still find teachers who don't pay attention to the learning stages of their students. They give questions and explain methods or formulas for solving math problems directly, without gradually developing an understanding from the concrete to the abstract, and without using concrete media to support learning. [8]. In fact, sometimes, before students fully understand how to work, the form or model of the problem has changed, causing students to feel confused due to a lack of conceptual understanding in the learning process. The use of concrete objects as a learning stage is a stage that is often overlooked or forgotten by teachers in the teaching and learning process.

Conventional methods are still widely used by teachers today, especially during the 2019-2021 pandemic, when online learning also utilized conventional methods. The conventional lecture method is claimed to be the most common learning method and approach in mathematics teaching [9]. With conventional methods that are centered on teachers through lectures, students will have difficulty learning mathematics which requires critical, logical and systematic thinking [10]. There are teachers who are still fixated on conventional learning methods such as lectures, which are considered less effective because they make students easily bored and passive [11]. The main weakness of the conventional approach is its neglect of students' thinking stages and its insistence on operating at an abstract level before students understand the material. As a result, the knowledge formed is temporary and easily forgotten.

The conditions that occur can be caused by a lack of attention from teachers to the needs of students and teachers being less precise in designing learning models and approaches for students, even though students' needs are an important thing in selecting an approach [12]. The demands of completing material according to the curriculum often cause students to neglect their conceptual development [13]. As well as the lack of teacher knowledge regarding learning models and approaches that can be used in mathematics learning and the assumption that conventional methods are the easiest to implement.

An analysis of student needs and characteristics should be conducted before the start of learning. This analysis then serves as a reference for designing the models and approaches to be used in the mathematics learning process [14]. One approach teachers can use in the mathematics learning process in elementary schools is the concrete pictorial abstract approach. This concrete pictorial abstract approach aligns with the theoretical foundations of cognitive development. According to Jean Piaget, elementary school-aged children, aged 7-11, are in the concrete operational phase, a stage in which they can already use logic using concrete objects [6]. This concrete pictorial abstract approach is also strengthened by Jerome Bruner's instructional theory which emphasizes a gradual representation system, stating that effective learning must go through three stages: enactive-iconic-symbolic [15]. The concrete pictorial abstract approach is new in Indonesia, but has been used for a long time in Singapore [16]. Having long been implemented in Singapore, the CPA approach has proven to facilitate students' understanding of mathematical concepts. Singapore has also consistently ranked among the countries with the best mathematical abilities in the world, never ranking higher than 3rd [17].

Previous research relevant to this study is the research conducted by Ulinnuha Yunianto entitled "The Effect of the Concrete Pictorial Abstract Approach on Improving Mathematical Problem-Solving Ability." This study found that the concrete pictorial abstract approach has an influence on improving mathematical problem-solving ability [18]. Another study relevant to this research is the study conducted by Eliza Nur Azizah, et al. entitled "The Effect of the Concrete-Pictorial-Abstract (CPA) Approach Assisted by Augmented Reality (AR) on Elementary School Students' Mathematical Critical Thinking Skills." This study found that there was an effect of the AR-assisted CPA approach on elementary school students' mathematical critical thinking skills [19].

Although much research has been conducted on the Concrete-Pictorial-Abstract (CPA) approach, most of the previous studies have focused more on critical thinking skills or problem-solving in general. There is still limited research that specifically examines the effect of the concrete pictorial-abstract approach on conceptual understanding of plane geometry, especially for elementary school students. Furthermore, much literature discusses concrete pictorial-abstract in educational contexts abroad, such as in Singapore, for example. However, its implementation in education in Indonesia still requires evidence to confirm its effectiveness.

Based on the disconnect between students' cognitive developmental phases and the approaches used in the classroom, elementary school-aged students in the concrete operational phase are often forced to understand abstract geometric concepts without going through the proper stages. If problems like this are allowed to continue, they will continue to have misconceptions that will hinder students' mathematical abilities at the next level. Therefore, this research is crucial to scientifically prove the use of the concrete-

pictorial-abstract approach as a solution to minimize failures in understanding mathematical concepts from an early age.

Based on the description above, the researcher is interested in conducting a study entitled "The Effect of the Concrete Pictorial Abstract Approach on Students' Conceptual Understanding." This study was conducted on second-grade students of SDI Miftahul Huda Plosokandang which was limited to the mathematics subject, namely " two-dimentional figure".

2. METHOD

This research was conducted at SDI Miftahul Huda Plosokandang located in Srigading Hamlet, Plosokandang Village, Kedungwaru District, Tulungagung Regency, East Java. A quantitative approach with a quasi-experimental research type was used in this study. This type of quasi-experimental research was used because of limitations in controlling other variables in the study, such as the presence of students who participate in tutoring outside of school, thus affecting their conceptual understanding. The pretest-posttest control group design research design was used in this study, where there will be two classes, namely the experimental class and the control class. This study only focuses on the effect of the concrete pictorial abstract approach on students' conceptual understanding of two-dimentional figure at SDI Miftahul Huda Plosokandang. In this study there are two variables, namely the independent variable (X) and the dependent variable (Y). The independent variable in this study is the concrete pictorial abstract approach (X). The dependent variable in this study is students' conceptual understanding (Y).

The population in this study was class II of SDI Miftahul Huda Plosokandang in the 2024/2025 academic year, consisting of 2 classes, namely class II-A and class II-B with a total of 34 students. Saturated sampling, which is included in nonprobability sampling, is a sampling technique used in this study, where all members of the population are used as research samples. The population size in this study is too small to be the basis for using saturated sampling. A total of 34 students from class II-A and II-B were used as samples so that the chance of error in generalizing is very small. The sample was divided into a control class and an experimental class. Class II-A with 19 students as the experimental class and class II-B with 15 students as the control class.

Data were collected through a written test. The written test was chosen because it suited the research needs, which aimed to determine students' conceptual understanding of the material on two dimentional figure. The test was administered to both the control and experimental classes. Two types of written tests were administered: a pretest and a posttest. The pretest was administered before learning or before the treatment was administered to determine conceptual understanding before learning. The posttest was administered after learning or after the treatment was administered to determine the extent of the influence of the concrete pictorial abstract approach.

The test instrument has been validated by experts and tested first on 10 students of grade II before being given to the experimental class and the control class. The test instrument consists of 10 questions on two dimentional figure geometry material to measure conceptual understanding. Data obtained from the test instrument trial in the form of questions will be tested for validity and reliability. Validity and reliability tests were analyzed using the SPSS 25 for Windows program. The hypothesis prerequisite test in this study includes two stages, namely the normality test and the homogeneity test. The independent sample t-test and Cohen's d test were carried out as hypothesis tests in this study. The t-test is used to answer the first hypothesis, namely Ha1: there is an influence of the concrete pictorial abstract approach on students' conceptual understanding of two dimentional figure geometry material, Ho1: there is no influence of concrete pictorial abstract on students' conceptual understanding of two dimentional figure geometry material. Meanwhile, Cohen's d test is used to answer the second hypothesis, namely Ha2: there is a large influence of the concrete pictorial abstract approach on students' conceptual understanding of the material on two dimentional figures, Ho2: there is no large influence of the concrete pictorial abstract approach on students' conceptual understanding of the material on two dimentional figures.

3. RESULTS AND DISCUSSION

The results and discussion data were obtained through a test to analyze the effect of the concrete pictorial abstract (CPA) approach on students' conceptual understanding of two dimentional figure geometry material at SDI Miftahul Huda Plosokandang. The test instrument was in the form of pretest and posttest essay questions on conceptual understanding with 10 questions each. The questions used were different questions with the same indicators and weights. The validated questions were tested on 10 grade II students and the results were tested for validity and reliability which were analyzed with the help of the SPSS 25 for windows program. The results of the instrument validity test showed that the question instrument was valid if rhitung > rtable. The rtable value can be seen in the r product moment value table. Because the respondents in this trial were 10 respondents. Based on the formula df = N – 2, so that df = 8 is obtained. The rtable value

for df = 8 is 0.632. The results of the validity test on 10 pretest and posttest questions show that the Correlation Product Moment (r) value for items 1 to 10 is generally greater than rtable with a significance value of less than 0.05. Therefore, all pretest and posttest questions are declared valid and can be used as research instruments.

The reliability test was carried out with the help of the SPSS 25 for Windows program after the question instrument was declared valid, with the instrument criteria known from the Cronbach's alpha value as follows:

Table 1 Reliability Criteria

No.	Cronbach's alpha	Criteria
1	Cronbach's alpha ≥ 0,900	Perfect Reliability
2	0,800 – 0,899	Strong Reliability
3	0,700 – 0,799	Acceptable Reliability (standard)
4	0,600 – 0,699	Reliability is questionable
5	0,500 – 0,599	Weak reliability
6	Cronbach's alpha ≤ 0,500	Not accepted

The results of the reliability test showed that the Cronbach's Alpha value obtained for the conceptual understanding pretest and posttest questions was 0.905. Based on the reliability criteria attached in Table 1, the pretest and posttest test instruments were declared to have perfect reliability.

After the questions were declared valid, a pretest and posttest were administered to the experimental class using a concrete pictorial abstract learning approach. The control class was given a pretest and posttest using conventional learning conducted by the researcher. After the researcher obtained the data or results of the test research instruments that had been given to the experimental and control class students, the researcher conducted prerequisite tests before conducting the hypothesis test. The prerequisite tests used were the normality test and the homogeneity test. The normality test is a statistical analysis used to determine whether the data used has a normal distribution or not, so that it can be used in parametric statistics [20]. The Shapiro-Wilk normality test was used in this study. The Shapiro-Wilk type normality test is used if the sample value is <50 (less than 50) [21]. This study used a sample size of 34 students, so the Shapiro-Wilk normality test will be used. Data is considered normally distributed if its significance level is >0.05. Using SPSS 25 for Windows, the results of the normality test for the pretest and posttest data for the experimental and control classes are as follows:

Table 2 Output of Normality Test of Conceptual Understanding Test Results

Tests of Normality

	Class	Shapiro-Wilk		
		Statistic	df	Sig.
Conceptual Understanding Test Results	Class A Pretest (Experiment)	.938	19	.238
	Class A Posttest (Experiment)	.952	19	.419
	Class B Pretest (Control)	.883	15	.053
	Class B Posttest (Control)	.919	15	.184

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Based on table 2, the output of the normality test for the conceptual understanding test results obtained using Shapiro Wilk, it can be seen that the significance value for the pretest and posttest of the experimental class is 0.238 and 0.419, while the significance value for the pretest and posttest of the control class is 0.053 and 0.184, so it is more than 0.05. Thus, it can be concluded that the data from the conceptual understanding test results are normally distributed.

The homogeneity test is a test conducted to determine whether the data from both classes have the same variance or not. Data is said to be homogeneous if the significance level is greater than 0.05. The homogeneity test in this study used the SPSS 25 for Windows program. The data used were the results of the posttest of students' conceptual understanding, which was previously used for the normality test. The results of the calculation of the homogeneity test of the posttest data from conceptual understanding using SPSS 25 for Windows are as follows:

Table 3 Output of Homogeneity Test of Conceptual Understanding Posttest Results

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Conceptual Understanding Posttest Results	Based on Mean	1.846	1	32	.184
	Based on Median	1.537	1	32	.224
	Based on Median and with adjusted df	1.537	1	28.376	.225
	Based on trimmed mean	1.604	1	32	.214

Based on Table 3. Output of the Homogeneity Test of Posttest Results, the Sig. value is 0.184 with a Lavene statistic coefficient value of 1.846. So it can be declared homogeneous because Sig. of 0.184 > 0.05.

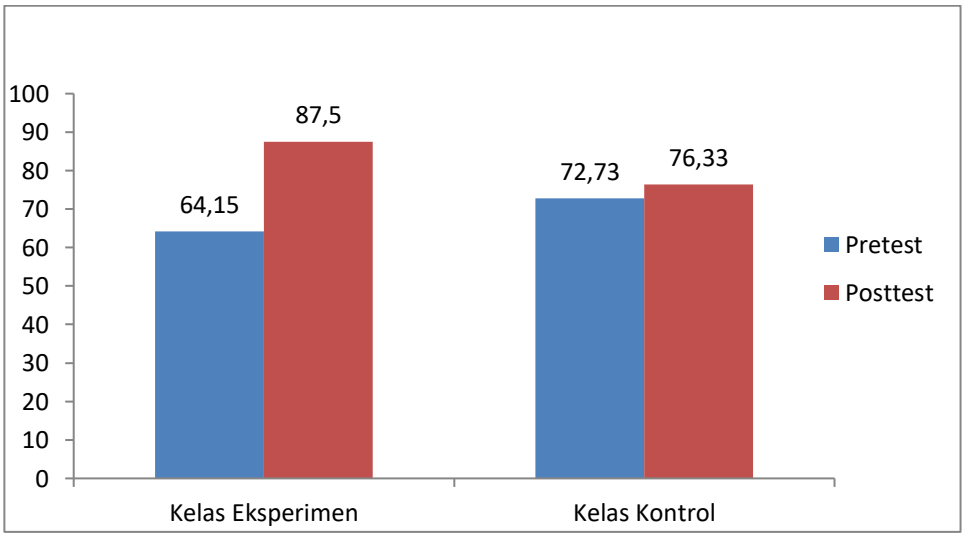

Figure 1. Comparison of Average Pretest and Posttest Scores

As presented in Figure 1, a contrasting comparison of conceptual understanding achievements between the two classes can be seen. Both started with relatively different starting points, the experimental class experienced a significant increase reaching 87.5 in the posttest stage. This is directly proportional to the findings in the field that the stages from concrete to abstract media helped students understand the concept of two dimentional figures better compared to the control class which only achieved an average of 76.33. The superiority of the experimental class proves that students' cognitive barriers regarding two dimentional figures can be overcome through the concrete-pictorial-abstract stages. The sharp increase in scores is not just a number, but also represents that manipulative media can bridge abstract thinking. Therefore, this approach can be recommended for elementary school teachers in teaching geometry so that students do not get trapped in memorizing formulas.

To strengthen the visual findings in the graph and prove the research hypothesis, an independent sample t-test using SPSS 25 for Windows and a Cohen's d test using manual calculations were conducted to ensure that the improvement in the experimental class was truly due to the influence of the concrete pictorial abstract approach and not due to chance. The results of the t-test in this study can be seen in Table 4 as follows:

Table 4 Independent Sample T-test Output

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Conceptual Understanding	Equal variances assumed	1.846	.184	3.797	32	.001	10.719	2.823	4.968	16.470
	Equal variances not assumed			3.656	24.730	.001	10.719	2.932	4.678	16.761

Based on table 4 of the independent sample t-test output, the sig. 2-tailed conceptual understanding value is 0.001 with a t-test coefficient of 3.797. Based on the decision-making criteria of $0.001 \leq 0.05$, Ha1 is accepted and Ho1 is rejected. So it can be concluded that there is an influence of the concrete pictorial abstract approach on students' conceptual understanding of flat shapes/two dimensional figure.

Based on the data analysis, the concrete pictorial abstract approach has been shown to have a significant impact on students' conceptual understanding. This influence is evident in learning outcomes and fulfillment of conceptual understanding indicators after learning using the concrete pictorial abstract approach. Fulfillment of conceptual understanding indicators includes:

a. Students are able to understand and restate a concept using their own words. The concrete stage helps students truly understand directly to be able to restate a concept, not just reading from a book and memorizing it. This stage involves students directly knowing and understanding a concept, in accordance with Jean Piaget's theory that children aged 7-11 years are in the concrete operational stage who can use logic using concrete objects [22].
b. With the concrete and pictorial stages, students are able to classify objects according to their concepts. Using real objects and pictures helps students analyze the shape and characteristics to classify polygonal plane shapes, because they can see the differences in shape and understand the characteristics of the shapes more clearly. This is in accordance with previous research, which states that with concrete objects, students will not be invited to imagine during the learning process, and it is easier to recognize the elements or characteristics of two dimentional shapes [23].
c. Students can provide examples and non-examples of a concept they are learning through a combination of concrete and pictorial stages. By learning that utilizes real objects around them, students can show examples of two dimentional figures, such as an example of a rectangle pointing to a blackboard, and a non-example of a rectangle pointing to a triangle ruler. This is in accordance with previous research which stated that realistic mathematics learning can improve students' understanding of the material on the properties of two dimentional figures [24].
d. By learning using the concrete pictorial abstract approach, students can present concepts in various forms of mathematical representation after learning with the concrete pictorial abstract approach. This concrete pictorial abstract stage supports multiple representations from concrete, to images, and then to symbols (abstract). When given pieces of paper in the shape of shapes, they can arrange them according to their imagination to form a unified image, then can write the name or result of the picture they made

from the pieces of paper. Activities like this are very popular with students because they are considered semi-playful and can be creative as desired without, of course, leaving the learning process at the forefront. This is in accordance with the findings of previous research, which found that playing while learning activities can improve learning outcomes [25].

e. Although it sounds difficult for 2nd grade elementary school children to develop the necessary and sufficient conditions of a concept, this is in accordance with previous research which states that the abstractness of concepts makes it difficult to learn mathematics, thus causing a lack of understanding of basic concepts which becomes an obstacle in understanding the necessary and sufficient conditions of a concept [26]. However, by learning using the concrete pictorial abstract approach, it can help students to develop the necessary and sufficient conditions of a concept, for example, students understand that the arrangement of flat shapes can be called a flat shape pattern, if the arrangement is repeated and regular.

f. Students can use and choose certain operating procedures and apply concepts in problem solving after learning with a concrete pictorial abstract approach. When composing new shapes and decomposing existing shapes, students use their own strategies and imagination to solve them. When given the task of arranging pieces of paper of flat shapes, they have their own strategies to solve them. Likewise, when given paper of unit shapes to be decomposed in groups, they also choose their own strategies. In accordance with previous research on tangram media to improve understanding of the concept of combined flat shapes, which states that tangram media can make learning interesting in composition and decomposition and can improve understanding of the concept of combined flat shapes [27]. The activity of using pieces of shapes and shapes paper with the syntax of the concrete pictorial abstract approach in this experimental class learning is almost the same as the tagram media in the form of puzzles, so that it is able to create interesting learning and increase conceptual understanding in students.

Before the concrete pictorial abstract approach was implemented, students still experienced difficulties with the material on plane figures and had not yet demonstrated the fulfillment of conceptual understanding indicators. This situation is in line with previous research, which stated that mathematics is a challenging and complex subject, so it is very common for students to fear and fail to understand the concept [28]. Before learning with the concrete pictorial abstract approach, students had difficulty restating the concept of plane shapes, difficulty in classifying almost similar shapes such as quadrilaterals and parallelograms, which ones were regular and irregular polygons. Students were only able to draw plane shapes by copying those in books without writing or connecting them with mathematical symbols, such as their characteristics. Previously, students were also unable to choose the strategy or procedure to use to solve problems, so when working on pretest questions, they often asked about the meaning of the questions.

All the findings that have been obtained are in line with the theory put forward by Bruner, in the form of a representation theory to show knowledge through 3 stages, namely enactive (depending on direct actions/manipulation of concrete objects), iconic (based on photos/images), and symbolic (based on symbols and language) [22]. The concrete pictorial abstract approach directly adopts this sequence, making it highly suitable for elementary school mathematics learning and proven to enhance conceptual understanding. Based on data analysis and supported by previous research, it can be concluded that learning using the concrete pictorial abstract approach influences students' conceptual understanding of plane geometry.

Cohen's d calculation is done using a formula, requiring the mean and standard deviation of both classes, namely the experimental class and the control class. It is known that the experimental class has a $\text{Mean}_1 = 87.05$ and $\text{Standard deviation}_1 = 6.924$, the control class has a $\text{Mean}_2 = 76.33$ and $\text{Standard deviation}_2 = 9.544$. From the data, the Pooled SD is calculated first before calculating Cohen's d. The Pooled SD obtained is 8.17. So the Cohen's d calculation can be carried out and the result is 1.31.

Cohen's d of 1.31 is greater than 0.8, so it can be concluded that there is a large effect between variable x and variable y. This means that Ha2 is accepted and Ho2 is rejected. Where there is a large influence of the concrete pictorial abstract approach on students' conceptual understanding of the material on plane figures with a Cohen's d value of 1.31.

The findings of the research results discussed previously indicate that the influence of the concrete pictorial abstract approach on students' conceptual understanding is not only statistically significant but also has practical significance in classroom learning. The significant effect of the concrete pictorial abstract approach can be seen from changes in students' abilities in meeting various indicators of conceptual understanding. Practically, the results of this study can be used as a guide for teachers, especially elementary

school teachers, to reform the way they present mathematics materials. Instead of providing formulas directly, the application of the concrete pictorial abstract approach is recommended so that elementary school students, especially lower grades, can build their own conceptual understanding through concrete-pictorial-abstract syntax experiences with manipulative objects in the surrounding environment.

4. CONCLUSION

Based on the results of research and discussion on "The Influence of the Concrete Pictorial Abstract Approach on students' conceptual understanding", the following conclusions can be drawn:

1. There is an influence of the concrete pictorial abstract approach on students' conceptual understanding of the material on two dimention figure shapes, as shown by the Independent Sample T-test with a Sig. value of 0.001 (≤ 0.05), so that Ha1 is accepted and Ho1 is rejected.
2. There is a large influence of the concrete pictorial abstract approach on students' conceptual understanding of the material on two dimention figure shapes, as shown by the Cohen's d test with a d value of 1.31 (≥ 0.8), so that Ha2 is accepted and Ho2 is rejected.

Overall, this study confirms that the concrete pictorial abstract approach is a crucial strategy for elementary school teachers to bridge concrete understanding and abstract material meaningfully.

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