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Analysis of Mathematical Concept Understanding in Geometry Through the Realistic Mathematics Education (RME) Approach

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Abstract

This study aims to analyze and describe the level of mathematical conceptual understanding of students in the Elementary Islamic Teacher Education Program (PGMI) on the geometry topic of the area of plane figures after participating in learning using the Realistic Mathematics Education (RME) approach. This study uses a quantitative approach with a quasi-experimental method. The subjects consisted of 43 sixth-semester PGMI students at the Faculty of Islamic Studies (FAI) of UIKA Bogor. The instrument used was a conceptual understanding test on the area of plane figures that had been validated and tested for reliability. The data were analyzed using descriptive statistics to measure the average score and describe the percentage of conceptual understanding based on the categories of very good, good, fair, and poor. The results showed that the average conceptual understanding score fell within the good category. Specifically, students demonstrated strong understanding in the indicator of restating a concept but showed weaknesses in the indicator of providing examples and non-examples of a concept. These findings indicate that the RME approach is quite effective in facilitating conceptual understanding of plane area material; however, further reinforcement is needed in the aspect of presenting concepts in various mathematical representations.

Keywords*: Mathematical Conceptual Understanding: Realistic Mathematics Education (RME).*

INTRODUCTION

Mathematical conceptual understanding is the main foundation for achieving success in mathematics learning, going beyond mere procedural skills or routine calculations. According to (Qetrani & Achtaich, 2022), conceptual knowledge helps students interpret problems, determine appropriate solution strategies, and even devise new approaches to solving different problems. These abilities do not always emerge if students only have procedural mastery. Without a strong conceptual understanding, students tend to only be able to solve standard problems and experience great difficulty when faced with contextual

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problems. Preliminary research results conducted on students with geometry problem-solving questions showed that 5 students or 11% of 43 students scored above the minimum passing grade. These results show that students with a good conceptual understanding are not only able to perform calculations, but also understand problems based on their context, identify related basic concepts, and use flexible reasoning in various conditions. (Hermaya & Hendrayana, n.d.).

His issue becomes particularly crucial when applied to geometry, especially the topic of the area of plane figures. Although this material appears simple and has been taught since the elementary school level, observations indicate that many students even up to the university level still frequently experience misconceptions. The primary misconception lies in the tendency to memorize formulas (for example, $L = P \times l$ for rectangles) without understanding why the formula works or how it is derived. This is consistent with the findings of studies that show (Fajari, 2020) many students continue to exhibit misconceptions about plane figures due to insufficient mastery of fundamental concepts. Errors frequently arise in understanding both the area and the properties of plane shapes, as students tend to rely on memorized formulas without knowing the meaning or conceptual basis behind them. As a result, they encounter difficulties when required to solve problems that demand conceptual understanding rather than merely applying formulas routinely.

This problem becomes a critical concern for students in the Elementary Islamic Teacher Education Program (PGMI). As future professional teachers at the elementary level, they hold a key role in establishing an appropriate foundation for mathematics learning among young learners. If PGMI students themselves do not possess adequate conceptual understanding, the teaching approaches they employ will tend to be procedural and focused mainly on delivering formulas, thereby perpetuating misconceptions among elementary school students. Therefore, strengthening the conceptual understanding of PGMI students especially in fundamental topics such as the area of plane figures is an urgent necessity to support improvements in education quality. Addressing this challenge requires a learning approach that shifts the focus from procedural memorization toward the construction of meaningful understanding. One approach proven to be effective is Realistic Mathematics Education (RME). Rooted in Freudenthal's philosophy of mathematics as a human activity, RME emphasizes that learning should begin with contextual or realistic situations relevant to students' experiences. Through the process of guided reinvention and the use of both horizontal and vertical mathematization, RME facilitates students in constructing concepts independently, progressing from real-world problems to formal mathematical concepts.

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Through the implementation of RME, PGMI students are expected to independently discover the formulas for the area of plane figures so that the understanding they develop becomes deeper and more enduring, rather than mere memorization. Based on this issue, this study was conducted to examine the level of conceptual understanding of PGMI students after participating in RME-based learning. This analysis is necessary as an empirical evaluation of the effectiveness of RME in teacher education and as a foundation for formulating relevant pedagogical recommendations. Although the Realistic Mathematics Education (RME) approach has been extensively researched and proven effective in improving primary school students' understanding of mathematical concepts, studies that specifically evaluate PGMI students' understanding of plane figure concepts are still relatively limited. A number of studies show that RME can help students build mathematical concept understanding through real contexts, mathematisation processes, and social interactions in learning. Research at the primary school level shows that the application of RME can improve students' understanding of flat shape concepts, reasoning skills, and problem solving by 45% (Aisah, 2025). and a review of literature collected over the past 10 years concludes that the Realistic Mathematics Education (RME) approach is effective in improving students' understanding of geometry concepts by linking mathematical concepts to real-life contexts (Sumarna et al., 2023). However, PGMI students as prospective primary school teachers have different characteristics in terms of learning experiences, professional needs, and demands for conceptual and pedagogical mastery. Therefore, further study is needed on the application of RME to PGMI students, particularly in understanding the concept of plane figures, so that they not only understand the concept procedurally but are also able to teach it meaningfully to primary school students. This study not only measures the success of RME implementation but also maps the conceptual understanding profile of prospective teachers through key indicators, namely translation, application, representation, and concept interrelationships. Thus, the purpose of this study is to analyse and describe the level of PGMI students' understanding of mathematical concepts in geometry material on the area of flat shapes through the RME approach.

RESEARCH METHODS

This study is a quantitative study using a quasi-experimental method with a pretest–posttest control group design. This study aims to determine the effect of applying the Realistic Mathematics Education (RME) approach on students' mathematical concept understanding of flat shape area geometry material. The research subjects consisted of 43 fifth-semester

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students from the Madrasah Ibtidaiyah Teacher Education Study Programme (PGMI) who took the Problem Solving course in the 2025/2026 academic year. The subjects were divided into two classes, namely an experimental class consisting of 22 students and a control class consisting of 21 students. The experimental class was given treatment in the form of learning using the RME approach, while the control class was given learning using the conventional approach.

The research instrument consisted of a test of mathematical concept comprehension on the subject of flat shapes, administered in the form of a pretest and posttest. The test was compiled based on indicators of mathematical concept comprehension and underwent validity and reliability testing prior to its use in the study. The data collection procedure began with administering a pretest to both classes to determine the students' initial abilities. Next, the experimental class was given treatment using the RME approach, while the control class followed the learning process without this approach. After the learning process was completed, both classes were given a posttest to determine the increase in students' understanding of mathematical concepts. The data obtained were analysed using descriptive statistics to determine the mean scores and improvement in students' mathematical concept understanding, as well as inferential statistics to test the difference in learning outcomes between the experimental and control classes. The research subject data are shown in Table 1 below.

Tabel 1. Number of Research Samples

No	Study Programs	Semester	Students
1	PGMI	VA	21
2		VC	22
Jumlah			43

The level of students' conceptual understanding of the geometry topic on the area of plane figures was analyzed based on the overall achievement of each indicator by all students. The degree of achievement was determined using the following percentage formula.

$$P = \frac{jumlah\ jawaban\ benar}{jumlah\ maksimal\ jawaban\ benar} x100\%$$

P represents the percentage of achievement for each indicator of conceptual understanding. The indicators of conceptual understanding used in this study refer to the framework proposed by Kilpatrick et al. in (Yanti et al., 2022) as presented in Table 2 below.

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Table 2. Mathematical Conceptual Understanding Indicators

Indicators of Mathematical Conceptual Understanding	Item Numbers
Restating a concept	1, 2, 3, 5
Providing examples and non-examples of a concept	7, 12
Presenting a concept in various forms of mathematical representation	6, 9, 11, 13,
Using, applying, and selecting appropriate procedures	4, 8, 10, 14, 15

RESULT AND DISCUSSION

A. Research Results

The test results illustrate the students' conceptual understanding of geometry, specifically the topic of the area of plane figures, among PGMI students. Table 2 presents the results of the pre-test and post-test after learning through the RME approach. Before this study was conducted in the PGMI Study Program, the students had previously received instruction on the topic of plane area. The following presents the results of the conceptual understanding test before and after the implementation of the RME approach.

Table 3. Categories of Conceptual Understanding Levels

Score range	Categori*	Convensional learning		RME	
		Total	Persentase	Total	Persentase
86 - 100	Very Good	0	0%	2	5%
71 - 85	Good	0	0%	25	58%
56 - 70	Fair	2	5%	15	35%
41 - 55	Poor	21	48%	1	2%
< 40	Very Poor	20	47%	0	0%
Total		43	100%	43	100%

From the table, it can be seen that there is a change in students' level of understanding of the geometric concept of plane area. In the initial test, although the students had previously received instruction on the material, most of them still demonstrated a very low level of understanding. After learning using the RME approach, a significant improvement occurred,

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in which the majority of students were able to understand the geometric concept of plane area much better.

The average score on the initial test was 38.2, while the average score after the implementation of the RME approach increased to 67.3. The comparison between these two scores shows an improvement of 57%. This improvement is also consistent with the achievement of each conceptual understanding indicator. Prior to the implementation of RME, the percentage of achievement for each indicator did not exceed 50%, even though the material had previously been taught.

Table 4. Percentage of Conceptual Understanding Achievement

Indicators of Mathematical Conceptual Understanding	Before RME	After RME
Restating a concept	41%	81%
Providing examples and non-examples	30%	57%
Presenting concepts in various mathematical representations	34%	66%
Using, applying, and selecting appropriate procedures	42%	62%

The data on students' mathematical concept comprehension achievement for each indicator was analysed before and after the implementation of the Realistic Mathematics Education (RME) approach. To facilitate interpretation and to see the comparison of improvements in concept comprehension for each indicator, the data was then presented in the form of the following bar chart:

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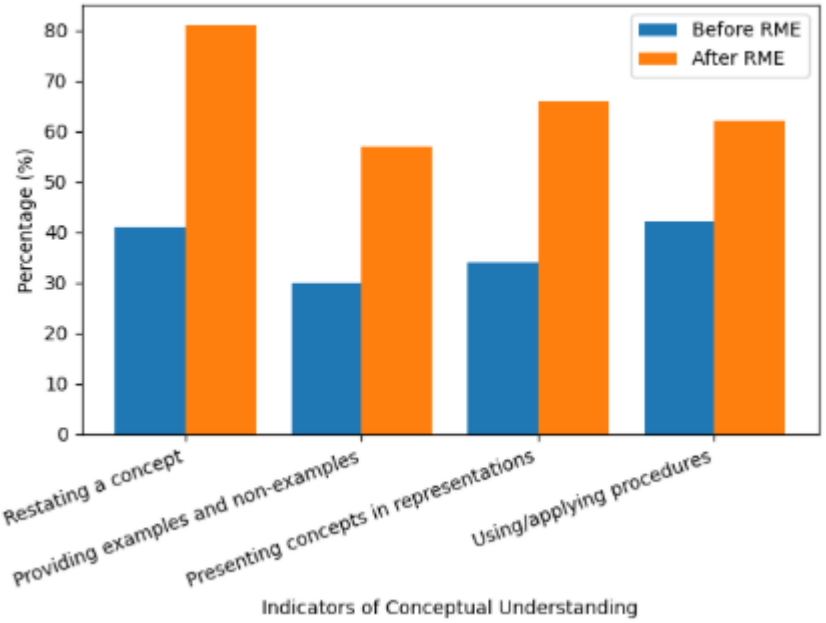

B. Discussions

Conceptual understanding is a fundamental ability that students must possess in mathematics learning. This ability is not merely related to recalling information, but also involves understanding, explaining, and applying concepts in solving various problems. Mulyardi (2002) and Zenti (2016) They state that conceptual mastery is a fundamental competency that students must possess in mathematics learning. Since mathematics develops through deductive reasoning, each new concept is built upon previously understood theories and principles, making the learning process sequential and continuous. Therefore, a concept cannot be fully understood without mastering its prerequisite concepts. Students also need to be able to recognize patterns, structures, and relationships among concepts so that they can learn subsequent material more easily. (Fauzan et al., 2020).

At the elementary school level, mathematics content may appear simple, but its complexity increases at higher levels. Therefore, teachers need to design learning experiences that are active and meaningful so that students are directly involved in constructing their understanding. Such involvement helps students perceive mathematics as an interconnected and meaningful discipline. If conceptual understanding is not established early, students will struggle to grasp more advanced material. The role of the

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teacher thus becomes crucial in fostering conceptual understanding. This is consistent with Regulation of the Minister of Education and Culture (Permendikbud) No. 58 of 2014, which emphasizes that effective learning is learning that helps students understand and apply mathematical concepts in problem solving. (Aisah et al., 2025).

In this context, geometry is a branch of mathematics that plays an important role and is taught from the elementary level through higher education. This field is closely related to everyday life because many objects we encounter are associated with shape and space. Understanding geometry helps individuals represent and describe their environment in a structured manner, while children's experiences interacting with objects around them serve as an essential foundation for learning geometry at later stages. (Andriliani et al., 2022). The basic geometry course is also a compulsory subject in the Mathematics Education study program (Khoirin Nisa et al., 2023). In everyday life, geometry is used to measure distances, calculate area or perimeter, and understand various structural forms; its learning process also fosters creativity, imagination, and curiosity through activities such as designing and creating models. (prasetyo et al., 2024).

In addition to understanding geometric content, PGMI students also need to understand how geometry instruction is delivered in elementary schools in accordance with students' cognitive development. Van Hiele in Van de Walle (2007:151) outlined five levels of geometric thinking, namely visualization, analysis, informal deduction, deduction, and rigor. (Ananda et al., n.d.). each of which describes the development of students' abilities in recognizing shapes, understanding their properties, connecting those properties, and eventually performing formal proofs.

In an effort to enhance conceptual understanding in geometry learning and mathematics in general, one approach that has proven effective is RME. The RME approach emphasizes that learning should begin with real-world contexts that are familiar to students so that the thinking process becomes more meaningful. Through discussions, group work, and solving contextual problems, students are encouraged to develop strategies, construct arguments, and independently discover mathematical concepts from the situations presented. (Aisah et al., 2025). Freudenthal in Sohilait (2021) explained that RME has three main principles, namely guided reinvention, in which students are guided to rediscover concepts through real-life situations; didactical phenomenology, which involves organizing learning materials based on contextual phenomena so that they are easier to visualize; and self-developed models, in which students generate their own representations that gradually transform into formal mathematical concepts.

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Gravemeijer & Doorman (1999) in Suhendar (2021) added that RME has five essential characteristics: the use of real-world contexts, the use of student-centered learning models, active student contribution, interaction and collaboration through group discussions, and an emphasis on conceptual connections and generalization. In addition, (Trimurtini, 2019; Salamah & Kelana, 2020) stated that the stages of RME learning include understanding contextual problems, explaining the elements of the problem with the guidance of the teacher, and solving the problem through strategies developed independently by the students, either individually or in groups.

In geometry learning, RME is highly relevant because this approach emphasizes the use of manipulatives, visualization, and exploratory activities that allow students to interact directly with geometric objects and understand their mathematical structures concretely. The implementation of problem-based learning within realistic contexts helps students connect their practical experiences with mathematical concepts and encourages critical and creative thinking skills. For example, the study *Impact of Realistic Mathematics Education (RME) Approach Assisted by Unit Cube Models on Fifth Grade Students' Understanding of Concepts* (2023) found that the use of unit cube models within the RME approach significantly improved students' conceptual understanding of three-dimensional shapes. In addition, evidence from systematic literature reviews indicates that students who learn through the RME approach demonstrate higher retention of geometric understanding compared to those who learn through conventional approaches. (Mailani et al., 2025).

CONCLUSION

Based on the results of quantitative data analysis in quasi-experimental research, it can be concluded that the application of the Realistic Mathematics Education (RME) approach has a positive and significant effect on PGMI students' understanding of mathematical concepts in flat shape geometry. This is demonstrated by an increase in the percentage of achievement in all indicators of mathematical concept understanding after the application of RME. The indicator of the ability to restate a concept increased from 41% before RME to 81% after RME. The indicator of the ability to give examples of concepts increased from 30% to 57%. Furthermore, the indicator of the ability to present concepts in various forms of mathematical representation increased from 34% to 66%, and the indicator of the ability to use, utilise, and select specific procedures increased from 42% to 62%.

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In addition, there was a significant shift in the category of students' conceptual understanding. In conventional learning, students' conceptual understanding was dominated by the categories of poor (48%) and very poor (47%). After applying the RME approach, most students were in the good (58%) and adequate (35%) categories, and some students even reached the very good category (5%). These findings indicate that the RME approach is effective in helping students understand plane geometry concepts in a more meaningful, contextual, and applicable way. The results of the study also show that the ability to provide examples of concepts and the ability to integrate various plane geometry concepts still need to be strengthened so that students' conceptual understanding becomes more in-depth and comprehensive.

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