

ANALYSIS OF MATHEMATICAL REPRESENTATION ABILITY ABULYATAMA UNIVERSITY STUDENTS IN SOLVING GEOMETRY PROBLEMS TRANSFORMATION

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Abstract: Mathematics is one of the important fields of science in developing students' logical and analytical thinking skills. However, in practice, many students still have difficulty in representing mathematical concepts, especially in transformation geometry material. This study aims to describe the mathematical representation abilities of students in the transformation geometry course. The type of research used is qualitative with a descriptive approach. The subjects in this study were fourth semester mathematics education students of the 2024/2025 academic year of FKIP UNAYA. The selection of subjects was based on the results of tests given to 15 students, from the results of the test, 3 students were selected as subjects representing each category of high, medium and low. The data collection technique used a mathematical representation test in the transformation geometry course and interview results. The data analysis technique used was to give a score to each subject's answer. The score was determined according to the mathematical representation indicators, namely: 1) Verbal representation; 2) Symbolic representation; 3) Visual representation. The results showed that 53.3% of students' mathematical representation abilities were in the low criteria, 26.7% of students were classified as medium criteria, and 20.0% were in the high criteria. Overall, students' mathematical representation abilities in answering transformation geometry questions were more dominant in the low criteria.

Keywords: *Analysis; Mathematical Representation Ability; Student Representation*

1. Introduction

In the 21 st century, education has become a crucial element in ensuring that students possess learning and innovation skills, as well as skills in using technology and information media (1). This is in line with opinion (2) which states that quality education is greatly influenced by quality teachers. In other words, only quality teachers are capable of improving the quality of education. Thus, preparing quality students who are able to compete globally is a challenge for educational institutions in adapting to developments occurring in the 21st century.

One way to address these challenges is by strengthening the learning process for various subjects to meet the needs of the times, including mathematics. Mathematics is a fundamental subject taught from elementary school to university. Success in mathematics learning depends heavily on the quality of the learning process.

According to (3) mathematics is not just a tool for thinking, but a tool for conveying clear and precise ideas, mathematics must be conveyed as something meaningful in accordance with the progress of the times. This shows that mathematics has a very important role in the world of education, especially in supporting the development of technology and science in the modern era.

One of the goals in learning mathematics is for students to be able to understand mathematical concepts, explain the relationships between concepts, and apply these concepts flexibly, accurately, efficiently, and appropriately in problem solving. To achieve this goal, a mathematics teacher is required to have a good understanding of concepts and adequate mathematical skills, one of which is the ability to represent mathematics (4).

According to (5), mathematical representation ability is the ability to express mathematical ideas in various forms, such as pictures, graphs, tables, diagrams, equations, symbols, writing, or words. This is in line with the learning process standards set by the National Council of the Teachers of Mathematics (NCTM), namely problem solving, reasoning and proof, communication, connections, and representation (6). Based on these standards, representation is one of the important aspects that must be developed in mathematics learning.

By having representation skills, students can convey ideas or solutions to a problem in various ways and not focus on just one form of presentation. (7) states that mathematical representation skills are the ability that a person has in expressing an idea, concept or mathematical concept in various ways or methods. Therefore, this ability is an important part of basic mathematical skills that must be developed by both students, university students, and teachers.

Representational skills are essential, especially in solving complex and abstract mathematical problems, such as those in transformation geometry. These skills help students simplify, model, and solve problems using various forms of representation, such as images and mathematical expressions, as well as by answering questions using words or written text.

In the curriculum structure of the Mathematics Education Study Program, Faculty of Teacher Training and Mathematics Education, Abulyatama University (FKIP UNAYA), the Transformation Geometry course is one of the courses classified as a compulsory course with a weight of 3 credits. This course discusses translation (shift), reflection (mirroring), rotation (rotation), and dilation (enlargement).

These materials require students to be able to accurately and meaningfully represent notation, symbols, images, graphs, equations, or other forms of mathematical expression. Therefore, mathematical representation skills are crucial to student success in this course.

According to (8), geometry is a field of science that studies the relationship between points, lines, angles, planes, as well as flat surfaces and geometric shapes. Budiarto in (9) states that the aim of learning geometry is to develop logical thinking skills, spatial intuition, and the ability to read and represent mathematical arguments.

According to Usiskin in (10), there are three reasons why geometry is important. First, geometry is the only science that can relate mathematics to the physical forms of the real world. Second, geometry is the only one that allows ideas from other fields of mathematics to be drawn. Third, geometry can provide a non-singular example of a mathematical system.

However, despite this, it turns out that many students still experience difficulties in solving transformation geometry problems. This is because transformation geometry is one of the learning materials in mathematics whose objects are abstract mental objects. According to research conducted by (11), students still have difficulty in understanding the basic concepts of transformation geometry and the application of various types of problems.

The results of previous research also showed that the mathematical representation ability of prospective teacher students in analytical geometry courses, especially on the topic of lines, is still relatively low. They are quite good at visual and symbolic representation, but have difficulty in verbal representation (12). Other research also shows similar results, as found by (7), in the material on probability distribution, students' mathematical representation ability is still relatively low.

Interviews conducted with lecturers teaching transformation geometry at the Faculty of Teacher Training and Education (FKIP) at UNAYA University revealed that most fourth-semester students in the Mathematics Education Study Program in the 2024/2025 academic year were only able to solve routine math problems. This means that students often struggle to understand and solve problems that differ from the examples provided. Furthermore, students struggle to translate transformation geometry problems into appropriate representations.

One factor suspected of influencing students' mastery of mathematical representation skills is their diverse educational backgrounds. It was previously known that the high school educational backgrounds of students in the Mathematics Education Study Program at Abulyatama University are very heterogeneous, with both high school (SMA) and vocational high school (SMK) backgrounds, which naturally have differences in their approaches to and learning of mathematics.

Based on the several things that have been explained, the researcher sees that it is very important to examine more deeply the extent of students' mathematical representation abilities. Therefore, the researcher is interested in analyzing "Students' Mathematical Representation Abilities in Solving Transformation Geometry Problems". The objective to be achieved in this study is to analyze the extent of students' mathematical representation abilities in solving transformation geometry problems.

2. Literature Review

2.1 Understanding Ability

The word "ability" in the Big Indonesian Dictionary (KBBI) comes from the word "capable", which means ability, skill, or power. A person is said to be capable if they can do something they are required to do (13). Ability can also be defined as the capacity a person possesses to perform a task or job.

(14) states that a person's ability will also determine their behavior and the results achieved. Ability is an inherent talent in a person to perform an activity physically or mentally, acquired from birth, through learning and experience.

2.2 Mathematical Representation Ability

The word "representation" in the Big Indonesian Dictionary (KBBI) is defined as something that represents or a represented state. According to (15), representation is a method of presenting ideas and relationships in mathematics. Presentation forms such as symbols, charts, and graphs are used to communicate mathematical ideas.

NCTM establishes five process standards that students must possess: problem solving, reasoning, communication, connections, and representation(6). Representation is one of the five process standards covered by NCTM. These five process standards are inseparable from mathematics learning, as they are interrelated in the mathematics teaching and learning process. The representation standard emphasizes the use of symbols, charts, graphs, and tables to connect and express mathematical ideas.

(16) states that mathematical representation is the ability to re-express ideas or concepts that have been received from a statement, problem, issue, or solution by using or replacing those ideas or concepts in various forms such as symbols, images, or other forms.

(17) states that representation is a mental image of the learning process that can be understood through a person's mental development and is reflected as visualized in verbal form, images, or concrete objects. This shows that the process of depicting something occurs in a person's mind. Then, the results of their thoughts are expressed in the form of statements, visuals, or notations.

The NCTM states that mathematical understanding and representation skills are very important aspects of the principles of mathematics learning. Understanding is the primary goal in learning mathematics and can be enhanced through the use of various forms of mathematical representation. Representational skills used in learning mathematics, such as physical objects, drawings, graphs, and symbols, will aid students' communication and thinking (6).

According to Jones (18), there are three reasons why representation needs to be developed in mathematics learning. First, fluency in translating between different types of representations is a fundamental skill students need to develop concepts and think mathematically. Second, mathematical ideas presented by teachers through various representations will have a significant impact on students' learning of mathematics. Third, students need practice in constructing their own representations to develop strong and flexible conceptual skills and understanding that can be used in problem-solving.

(19) classifies representations into three forms: visual representations, which include images, diagrams, graphs, and tables; symbolic representations, which include mathematical notation and statements, as well as algebraic symbols; and verbal representations, which are expressed in written text or spoken language. Vilagas in (20) categorizes mathematical representations into three groups. The first is verbal representation, meaning students can present and solve problems in written text. The second representation, pictorial representation, means students can present a problem in the form of a picture, diagram, or graph. The third representation,

symbolic representation, means students can present and solve a problem in the form of a mathematical model.

The standards for mathematical representation skills established by NCTM include: first, using representations to organize and communicate mathematical ideas; second, selecting, applying, and interpreting mathematical representations in problem solving; and third, using representations to model and interpret mathematical, physical, and social phenomena. Developing mathematical representations requires attention to indicators for achieving mathematical representation skills (6).

This quote clearly demonstrates that representation plays a crucial role in mathematics learning because it facilitates students' communication of mathematical ideas, enabling them to effectively solve mathematical problems.

Several experts argue that mathematical representation skills are essential for students studying mathematics, enabling them to convey mathematical ideas and various mathematical problems in various forms, such as symbols, mathematical models, images, or concrete objects.

2.3 Indicators of mathematical representation ability

According to Mudzakir in (6), in measuring mathematical representation ability, it is grouped into three aspects of representation, namely visual representation, symbolic representation, verbal representation. Not only that, he also describes several indicators of each aspect of mathematical representation which are presented in table 1 as follows.

Table 1. Mathematical Representation Ability Indicators

Number	Representation	Operational Forms
1	Visual Representation	Representing data or information from a diagram, graph, or table representation
	a. Diagrams, tables, or graphs	Using visual representations to solve problems
2	Symbolic Representation (mathematical equations or expressions)	b. picture
		Create drawings of geometric patterns
3	Verbal Representation (written words or text)	Create drawings to clarify problems and facilitate their solution
		Create mathematical equations or models from other given representations
4	Mathematical Representation (mathematical symbols or expressions)	Make conjectures from a number pattern
		Solve problems involving mathematical expressions
5	Mathematical Representation (mathematical symbols or expressions)	Create a problem situation based on the data or representation provided
		Write an interpretation of a representation
6	Mathematical Representation (mathematical symbols or expressions)	Write steps to solve a mathematical problem in words
		Create a story that fits a given representation
7	Mathematical Representation (mathematical symbols or expressions)	Answer questions using words or written text

Adopted from: Mudzakir in (6).

3. Method

This research is a qualitative study with a descriptive approach and a triangulation design. Respondents in this study were 15 students from the class of 2023, with three research subjects selected using purposive sampling, representing each category of high mathematical representation ability (1 person), medium (1 person), and low (1 person). The research instruments were test questions and interview guidelines. The interviews were semi-structured, based on several predetermined questions. The test instrument consisted of three descriptive questions on transformation geometry. Data analysis used the Miles and Huberman model in (2): data reduction, data presentation, and conclusion drawing.

After the instruments were distributed and completed by the research respondents, scoring was carried out. The next stage was calculating the mathematical representation ability scores of the research respondents based on an assessment rubric with a scale of 0 - 4 by Ernawati in (21).

$$\text{Score} = \frac{\text{Score obtained}}{\text{Maximum score}} \times 100$$

So that the category of mathematical representation ability is obtained, the provision of criteria aims to determine the category of students' mathematical representation ability. The criteria for assessing mathematical representation ability can be seen in the following table.

Table 2. Provisions for Mathematical Representation Ability Categories

Score	Category
$80 < x \leq 100$	Tall
$60 < x \leq 80$	Currently
$x \leq 60$	Low

Source: [21]

4. Findings

The results of the study on students' mathematical representation abilities revealed that 8 students were categorized as low, 4 students as medium, and 3 students as high. Three students were then selected as research subjects from each category of mathematical representation ability. Interviews were then conducted with the three selected students based on their answers.

After interviewing the selected subjects, several factors identified as contributing to the difficulties experienced by students in the Mathematics Education Study Program, Faculty of Teacher Training and Education, Universitas Negeri Yogyakarta (UNAYA). Some students were able to understand and solve the problems well, but others remained confused and even failed to answer the problems at all. Some students admitted to forgetting how to solve the problems, not memorizing the formulas, and having difficulty understanding the content of the problems.

Overall, students revealed that the main difficulty in solving problems was due to a lack of basic understanding of the material in the transformation geometry course. This resulted in poor mathematical representation skills, which are necessary for solving various types of problems, whether visual, symbolic, or verbal.

5. Discussion

Based on student research data, the mathematical representation ability of fourth-semester mathematics students from the 2023 intake at the Faculty of Teacher Training and Education, Universitas Negeri Yogyakarta (UNAYA) was generally lower. This was evident from the test results of all sampled students, with 53.3% categorized as low, 26.7% as moderate, and 20.0% as high, based on the assessment rubric.

Based on the categorization using the mathematical representation ability indicator, students' visual representation ability fell into the moderate category, at 68.3%. This was evident from several students' ability to correctly draw shadow points to solve problems and to accurately answer questions using visual representations.

Students' symbolic representation ability fell into the high category, at 76.3%. This indicates that most students were able to correctly answer question number two using mathematical equations or expressions. They were able to identify the information provided in the problem and apply it in symbolic form appropriately.

However, some students still experienced difficulty understanding the problem and forgot the necessary formulas. This finding also confirms that one type of

representation is not always sufficient to describe a mathematical concept completely, so that other complementary representations are needed.

Students' verbal representation ability, or ability to express themselves verbally, was categorized as low, at 35%. This indicates that many students experience difficulty when solving problems requiring verbal explanations. This difficulty is caused by the large amount of information contained in the problems and the complex thought processes that make it difficult to express them clearly and systematically.

Based on the classification of mathematical representation ability assessment results into high, medium, and low categories, it was found that most students were only able to answer question number two well, which relates to symbolic representation. However, on questions number one and three, which involve visual and verbal representation skills, students still experienced difficulties, such as confusion in determining the coordinates of the image point and difficulty explaining the answer using words.

Therefore, it can be concluded that although some students fall into the high and medium categories, they still demonstrate weaknesses in certain aspects of mathematical representation ability. Overall, students still need to improve their skills in expressing mathematical ideas through images, symbols, and verbal explanations in a balanced manner to better understand and solve problems.

Based on the above results, it can be concluded that the mathematical representation skills of Mathematics Education students at the Faculty of Teacher Training and Education, Universitas Negeri Yogyakarta (UNAYA), are not yet optimal. Some students are able to draw shadows on graphs, but are unable to solve the problem completely. Furthermore, some students are able to solve problems but still make errors in using the correct formula, resulting in inaccurate solutions.

Students' ability to convey answers verbally is also still low. This was evident during interviews, where students appeared to have difficulty explaining their answers verbally. This situation indicates a lack of in-depth understanding of the basic concepts of transformation geometry.

When solving problems, students tend to rely on previously provided examples. They become confused when faced with problems that differ from the examples they have studied. This reliance indicates that their conceptual understanding is still limited and incomplete, making it difficult for students to apply their knowledge in various contexts.

These findings have not been scientifically proven and are limited to field observations, which may or may not be a contributing factor to students' poor mathematical representation skills in solving transformation geometry problems.

6. Conclusions and Recommendations

Based on the research conducted, overall, students' mathematical representation skills are still predominantly in the low category, particularly when solving transformation geometry problems. This finding indicates that students' mathematical representation skills are not yet fully optimal.

It is recommended that future research involve a larger and more diverse group of subjects, such as from different classes or study programs. Furthermore, more varied and in-depth instruments, including classroom observations or project assignments, or in-depth interviews, will be used to obtain more comprehensive and valid results in describing students' mathematical representation skills.

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