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Student Representation of Mathematical Thinking in Mathematical Problem-Solving

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ABSTRACT

Students who want to become teachers represent their mathematical reasoning when they solve mathematical problems using case studies and qualitative techniques. Data were gathered from the vignette results of student work. They are using snowball sampling for subject selection. Using snowball sampling for subject selection. Three third-semester students from Parepare State Islamic Institute's Mathematics Education Study Program served as the study's subjects. Data collection is done through documentation. The stages of data reduction, data presentation, inference, and verification were all used to study the data. As a consequence of meeting all markers of mathematical thinking representation, the S1 and S2 subjects with high and moderate academic talents had good mathematical thinking representation abilities. Because S3 students with limited intellectual skills need help to still represent mathematical ideas.
***Keywords**: Mathematical, Representation, Pre-Service, Teacher, problems, vignette*

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INTRODUCTION

Mathematics is one of the compulsory subjects at all levels of education, from elementary school to high school (Suastika, 2021; Winarso, 2018). The success or failure of learning mathematics depends on the learning process (Boudon et al., 2020; Romaito et al., 2021; Saad, 2020). In this case, the teacher plays a central role in learning mathematics. One of the teacher's roles is to help students understand the basic concepts of mathematics (Cho & Kim, 2020; Herna et al., 2016; Saputra et al., 2021). To carry out this role, a mathematics teacher must have adequate mathematical knowledge and abilities, one of which is the ability to represent mathematical thinking.

Representation of mathematical thinking is part of the essential abilities of mathematics that must be developed either by students, students, or teachers. Representation skills are the key to successful mathematical problem-solving (Krawec, 2014; Samad et al., 2020). The representation of mathematical thinking acts as a way of expressing mathematical ideas and how students understand and use their mathematical concepts. This shows that the use of representation in the form of a broad model (area model) can help students understand fraction division (Jaming & Moran, 2000; Köklü & Jakubowski, 2010).

Mentions five mathematical abilities that students, namely must possess: 1) learning to communicate (mathematical communication); 2) learning to reason (mathematical reasoning); 3) learning to solve problems (mathematical problem solving); 4) learning to link ideas (mathematical connection); 5) learn to represent ideas (mathematical representation) (NCTM, 2000). In mathematics, students must have mathematical communication skills to reason well (Bakar & Ismail, 2019; Pratiwi et al., 2020; Utari et al., 2020). The reasoning is an essential tool in mathematics and everyday life. Good reasoning skills are the key for students to solve problems and link various ideas in mathematics so students can represent their ideas (Harris et al., 2009; Sullivan et al., 2009). For students to achieve these five abilities in learning, teachers must master them first.

Prospective mathematics teachers must have good mathematical thinking representation skills, namely knowing how a mathematical idea can be represented to facilitate students understand the concept better (Boote & Boote, 2018; Tohir et al., 2020). Teachers must be able to translate challenging mathematical ideas into a representation that can be understood by their students (Chamberlin, 2005). To do that, prospective teachers must be facilitated with representational abilities that are useful in teaching mathematics, such as problems in the form of stories, pictures, situations, and accurate material.

The best way to help students understand mathematics through representation is to encourage them to find or create a representation as a tool or way of thinking in communicating mathematical ideas (Ishabu et al., 2019; Pratiwi et al., 2020). Therefore, this ability to represent is needed to help them convey ideas so that they are contained in written form or change from abstract to concrete so that they are easier to understand. This ability to represent also helps to find and create a tool or way of thinking to convey these mathematical ideas.

According to (Ahmad et al., 2021; Jaming & Moran, 2000), representation can be expressed as internal and external representation. Thinking about the mathematical ideas that are then communicated requires external manifestations in the form of verbal images and concrete objects. Finding a mathematical argument that allows the mind to work based on that idea is an internal representation. Internal representations cannot be perceived because they exist in the mind.

According to (Barthel et al. 2013; Krawec, 2014; Lee et al., 2019), representation can be classified into three, namely: 1) visual representation (pictures, graphic diagrams, or tables), 2) symbolic representations (mathematical statements/mathematical notations, numeric/algebraic symbols), and 3) verbal representations (written text/words). State that the ability to represent mathematical thinking is the ability to present notations, symbols, tables, pictures, graphs, diagrams, equations, or other mathematical expressions in other forms (Barthel et al., 2013; Mainali, 2021). In this study, the representation of mathematical thinking that will be assessed is the representation of images, written text, equations, or mathematical expressions.

Several studies have analyzed the ability to think mathematically and represent prospective teacher students. One of them is done by (Li et al., 2021; Ping Ong et al., 2014). The study compared the mathematical representational thinking abilities of teacher candidates who were given CPA (Concrete Pictorial Abstract) learning and conventional learning based on initial mathematical skills. The results show that the power of prospective teacher students who are given CPA learning has a better mathematical representation ability. This study only describes the ability to think mathematically to represent future teacher students based on mathematical skills determined from the cumulative achievement index.

Given the importance of the ability to represent mathematical thinking and student-teacher candidates who are prepared to become teachers who can help students represent mathematical ideas in learning, this study aims to determine the ability to represent mathematical thinking of prospective teacher students in solving mathematical problems. Because the role of the teacher determines the quality of learning, the results of this study are expected to provide an overview of the quality of prospective teachers when conveying concepts in class. In addition, it can give insight to future teachers to further improve their mathematical thinking representation skills through experience and practice in solving mathematical problems to have good mathematical thinking representation skills.

METHODS

This research uses a qualitative approach. Qualitative research is used to investigate the state of natural objects, with the researcher as the primary tool, and qualitative research findings emphasize meaning rather than generalizations (Khaleghi et al., 2021; Tammeleht et al., 2021). The type of study used in this study is a case study. A case study is an intensive, spatially, and temporally limited description and analysis of a phenomenon, social unit, or system. (Saad, 2020; Tohir et al., 2020). The design of the case study in this study was undertaken to gain an in-depth understanding of the situation and meaning of the mathematical representation of thought that can be derived from the results of the cartoon; The focus is on the process, not the result.

This study used snowball sampling as a subject-taking technique (Andriani et al., 2021). The subjects of this study were three third-semester students of the Mathematics Education Studies Program at Parepare State Islamic Institute. The determination of the topic in this research is based on the problems studied, namely the representation of the mathematical thinking of future students teaching mathematics. The academic skills of the students are very different, so the subjects examined consist of 1 student with high intellectual knowledge (GPA 3.50), a student with moderate academic skills (3.00 GPA <3.50), and a student with low academic skills (GPA <3.00).

The technique used to collect the data during the research is the documentation and data of the student's work in the results of the cartoons. A cartoon is a scenario with stories/cases/classroom conversations written on paper. Indicators of representation of mathematical thinking in research, namely: the creation of geometric figures to clarify problems, facilitating their realization (image representation); creating a problem situation from given data or representations, writing an interpretation of a representation, and writing steps to solve a mathematical problem in words (word representation or written text); Create equations or mathematical models from other given representations and solve problems with mathematical expressions (display equations or mathematical terms).

The data analysis technique, according to the qualitative data analysis, is performed interactively and takes place continuously until data saturation ("Analysis of Quantum Learning Model with Peer Assessment on Achievement Studentâ€TMs Critical Thinking Skill in Mathematics," 2019; Pratiwi et al., 2020; Wulandari et al., 2020). Data analysis was performed in the data reduction, presentation, conclusion, and verification stages.

RESULT AND DISCUSSION

The questions used to measure the mathematical imagination of prospective mathematics teacher students are analytical geometry questions in the following areas.

Find the equation of the tangent to the circle $x^2 + y^2 + 2y - 3 = 0$, which passes through the point (2,1). The following is an example of an S1 subject answer which can be seen in image 1.

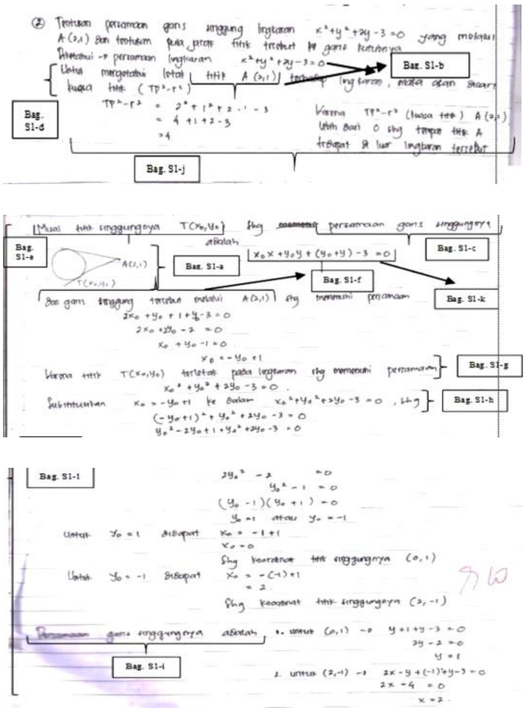

Figure 1. Answer Subject S1

Based on the answer to the subject of S1 in Section. S1-a above, subject S1 has been able to make geometric figures to clarify problems and facilitate solutions. In this case, the subject of S1 can interpret the situation in the form of an image so that it will be easier to solve the problem.

Technical answers S1 in the section. S1-b above shows that the subject of S1 may have created a problematic situation based on the given data or representation. It is proved that the issue of S1 can write the information found in the problem, namely the equation of the circle $x^2 + y^2 + 2y - 3 = 0$ and the known point (2,1) in the problem.

In answer to the subject of S-1 Part. S1-c shows that the issue of S1 can write an interpretation of a representation. This means that from the information that has been reported previously, the subject of S1 can find out the direction of the questions in the problem. It is proven that the issue of S1 can find and write down what problems must be solved in the situation, namely determining the equation of the tangent to the circle.

S1 subject answers in Section. S1-d up to Bag. S1-i shows that the issue of S1 can write the steps for solving mathematical problems in words. In this case, subject S1 has written down the stages that must be done in solving problems systematically.

S1 subject answers in Section. S1-k, the subject of S1, can make an equation or mathematical model from other representations given. In answer to Bag. S1-j shows that when the subject of S1 already knows the information obtained in the problem, then the step taken by the subject of S1 is to find the power of point A on the circle. Because the power of point A on the circle lies outside the circle. While in Bag. S1-k, after subject S1 knows that the power of point A on the circle is outside, then the next step is for subject S1. For example, there is a point that lies on the circle by taking any point, namely (x_0, y_0). Then the subject of S1 determines the equation of the tangent to the circle at point T by making a mathematical model, namely $x_0x + y_0y + (y_0 + y) - 3 = 0$.

In answer to the subject of S1 Part. S1-l, the issue of S1 has solved problems by involving mathematical expressions. It is proven that the S1 subject can solve problems by writing down the process systematically and using mathematical models. With a coherent stage, the issue of S1 can solve the problem correctly.

The following (Figure 2) is an example of the answer for the subject of S2. Answers subject S2 Bag. S2-a shows that the subject of S2 has been able to make geometric figures to clarify problems and facilitate solutions. It can be said that the issue of S2 can interpret the situation in the form of an image, making it easier to solve the problem.

In answer to Bag. S2-b, the subject of S2, has created a problem situation based on the data or representation given. S2 issues can also write down the information found in the problem, namely the equation of the circle $x^2 + y^2 + 2y - 3 = 0$ and the point (2,1), which is known in the issue. In answer to Bag. S2-c, the subject of S2, can write an interpretation of a representation. It is proven that the subject of S2 can write down what problems must be solved in the situation, namely finding the equation of a tangent to a circle. S2 issues can determine the problem to be solved based on the information that has been previously written.

Answer Bag. S2-d up to Bag. S2-h, it can be seen that the subject of S2 can write the steps for solving mathematical problems in words. In this case, the S2 issue has written down the stages that must be carried out in solving problems systematically in answer to the subject of the S2 Bag. S2-i, the subject of S2, can make equations or mathematical models from other representations given. After the issue S2 knows the information on the problem, the step taken by the subject of S2 is to find the power of point A on the circle. Because the influence of point A on the process is outside the ring, the next step is Subject S2. Suppose a point lies on the loop by taking any point, namely $S(x_0, y_0)$. Then the subject of S2 determines the equation of the tangent to the circle at point S by making a mathematical model, namely $x_0x + y_0y + (y_0 + y) - 3 = 0$.

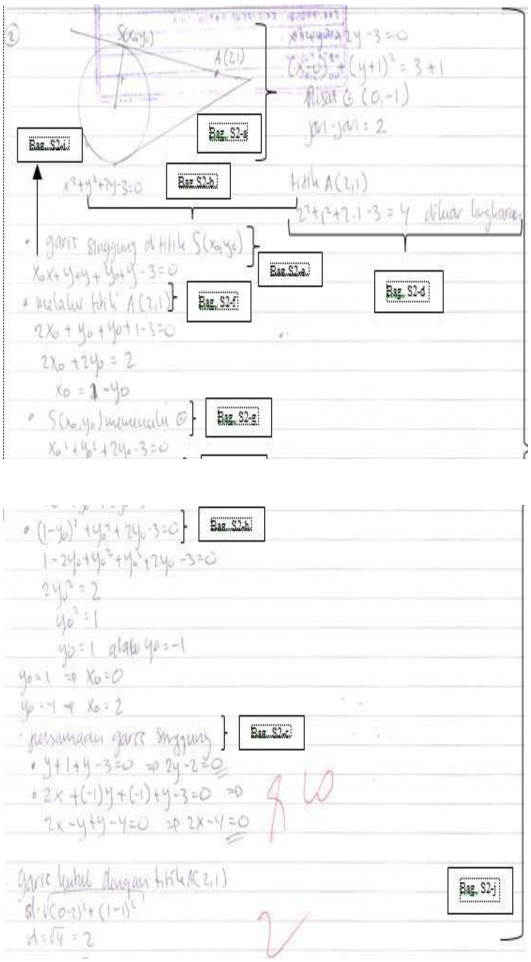

Figure 2. Answers to S2 Subjects

Based on the answer to the subject of S2 in Section. S2-j shows that the issue of S2 has solved problems by involving mathematical expressions. It is proven that the master's topic can solve problems by writing down the process systematically and by using mathematical models. The settlement process carried out by the S2 subject is carried out coherently so that the S2 issue can solve the problem correctly.

The following is an example of an S3 subject answer which can be seen in Figure 3.

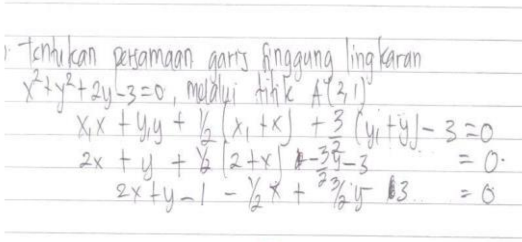

Figure 3. Answers to S3 Subjects

Based on the answer to argument S3 above, it can be said that question S3 could not create geometric figures to clarify the problem and facilitate the solution, could not produce a problem situation based on the data or representations given, and could not write an interpretation of a representation, was unable to write steps to solve mathematical problems with words, was unable to create mathematical equations or models from other representations of data and could not solve problems with mathematical expressions.

The S3 subject immediately wrote down the solution to the problem without writing down the information contained in the issue. As a result, the subject of S3 is wrong in solving the problem. Subject S3 did not determine the power of point A on the circle, so subject S3 did not know the location of point A in the process. The subject of S3 solves the problem by using the fair share rule. Subject S3 believes that point A lies on the circle. However, the power of point A on the process is outside. The subject of S3 should assume the end of tangency first, then determine the solution to the problem.

Based on several findings from this study, the subject of S1 and S2 met all indicators of representation of mathematical thinking. This means that the ability to represent mathematical thinking S1 subjects with high academic skills and S2 subjects with moderate intellectual abilities have good mathematical thinking representation abilities. At the same time, the ability to represent mathematical thinking of S3 issues with low academic skills based on vignette analysis is still lacking because none of the indicators of mathematical thinking representation appear in the answers of S3 subjects. One of the indicators not met by the issue of S3 was making geometric figures to clarify problems and facilitate resolution. This follows the research conducted by (Köklü & Jakubowski, 2010; Krawec, 2014; Samad et al., 2020), where the results of their study showed that the image representation ability of students still did not show a significant increase. The test results show that representing objects in the form of images is still something that is considered difficult by students.

Students' mathematical representation ability is not only influenced by academic ability. Still, it can also be affected by other factors such as using media in learning and experience or practice in solving mathematical problems. The representation of mathematical thinking can be improved, one of which is using a medium in education. This follows research conducted by (Bernard & Setiawan, 2020; Romaito et al., 2021; Selvy et al., 2020). The study results show that learning using GeoGebra media has succeeded in increasing students' mathematical representational thinking abilities (Bernard & Setiawan, 2020; Romaito et al., 2021; Selvy et al., 2020). To improve the ability to think of the mathematical representation of prospective teacher students, media is needed in learning and facilitating a more profound experience in solving mathematical problems (Izzatin et al., 2020; Leksono & Fitriatien, 2021; Pascual & San Pedro, 2018). Based on the results of this study, the ability to represent mathematical thinking is essential for prospective mathematics teacher students to make geometric figures in clarifying problems to facilitate solving, writing information based on existing data, writing steps for solving mathematical problems, making equations, or mathematical models. And solve problems involving mathematical expressions.

CONCLUSION

Based on the results of research and discussion, the ability to represent mathematical reasoning in S1 subjects with high academic level and S2 subjects with moderate intellectual ability based on the vignette results shows that S1 subjects and S2 have good mathematical representation capabilities because you meet all the conditions. Indicators of the representation of mathematical thought. While the ability to think mathematically and present S3 subjects with general academic knowledge is still lacking, the analysis of the vignette results does not meet all indicators. The ability to represent the mathematical thought of future teachers training students is not only influenced by their academic results. However, it is also influenced by other factors such as learning materials, experiences, and practice. In this case, media in learning and lots of math problem-solving classes are needed to have good math thinking skills. Aspiring math teachers should have good math thinking skills to help students create geometric figures to clarify problems for easy completion, write information based on existing data, write steps to solve math problems, create mathematical equations or models, and solve problems. Problems with mathematical expressions.

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