Describing Students' Representation Ability: Focus on Functions and Its Inverses Topic

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Abstract

The topic of functions is one of the topics in mathematics that involves various representations completely such as verbal representation, visual representation, and symbolic representation. So, this research aims to describe students' mathematical representation abilities on the topic of functions and its inverses. This study is a quantitative descriptive research that involved 15 eleventh-grade students at one of high schools in Sungai Penuh, Jambi, were selected through total sampling techniques as research subjects. The researcher gave three mathematical representation ability test problems, each of which represented indicators of verbal representation, visual representation, and symbolic representation. Students' answers were analyzed descriptively. The results of the study showed that in general students' mathematical representation abilities were relatively low, most students had tried to solve the problems but were not give complete answer. Therefore, teachers are expected to use appropriate learning methods to help students improve their mathematical representation abilities.

Keywords: *Mathematical Representation Ability; Functions and Inverses; Symbolic Representation; Verbal Representation; Visual Representation.*

Abstrak

Topik fungsi merupakan salah satu topik dalam matematika yang melibatkan berbagai representasi secara lengkap seperti representasi verbal, representasi visual, dan representasi simbolik. Maka dari itu, penelitian ini bertujuan untuk mendeskripsikan kemampuan representasi matematis siswa pada topik fungsi dan inversnya. Penelitian ini merupakan penelitian deskriptif kuantitatif yang melibatkan 15 siswa kelas XI di salah satu SMA di Sungai Penuh, Jambi, yang dipilih melalui teknik *total sampling* sebagai subjek penelitian. Peneliti memberikan tiga soal tes kemampuan representasi matematis yang masing-masing mewakili indikator representasi verbal, representasi visual, dan representasi simbolik. Jawaban siswa dianalisis secara deskriptif. Hasil penelitian menunjukkan bahwa secara umum kemampuan representasi matematis siswa tergolong rendah, sebagian besar siswa sudah mencoba menyelesaikan soal tetapi belum memberikan jawaban yang lengkap. Oleh karena itu, guru diharapkan menggunakan metode pembelajaran yang tepat untuk membantu siswa meningkatkan kemampuan representasi matematisnya.

Kata Kunci: Kemampuan Representasi Matematika; Fungsi dan Invers; Representasi Verbal; Representasi Visual; Dan Representasi Simbolik.

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INTRODUCTION

Mathematics is a discipline that focuses on the study of numbers, formulas, and patterns, forming the foundation for understanding quantitative relationships. As a symbolic language, mathematics fulfills both practical and theoretical roles: it provides a means to express quantitative relationships and serves as a powerful tool for solving everyday problems (Asri & Noer, 2015). Effective participation in mathematics learning requires the development of robust mathematical thinking skills, which are critical for understanding and applying mathematical concepts. Among these skills, representation holds a central role as one of the five fundamental mathematical thinking abilities that students must possess and master. Representation enables students to interpret, express, and connect mathematical ideas in various forms, making it an essential component of successful mathematics learning (Marthalena et al., 2021).

Mathematical representation ability refers to students' capacity to create and use symbols, diagrams, graphs, and mathematical expressions effectively. It encompasses the ability to transform various mathematical notations—such as symbols, tables, images, graphs, diagrams, and equations—into other equivalent forms, enabling a deeper understanding of mathematical concepts (Hartono et al., 2015). The representations produced by students reflect their interpretation and expression of mathematical ideas, serving as tools to articulate their reasoning and strategies when solving problems. This ability plays a critical role in mathematics learning, as it facilitates students' comprehension, communication, and problem-solving processes, making it an essential skill for success in mathematics education.

The importance of mathematical representation lies in its ability to help students understand mathematical concepts through visual, symbolic, and written forms (Rahayu & Hakim, 2021). By employing appropriate representation methods, students can translate abstract mathematical ideas into more concrete and comprehensible formats, thereby enhancing their conceptual understanding. The use of accurate representations enables students to simplify and approach complex problems more effectively. Conversely, the use of incorrect or

inappropriate representations can hinder problem-solving efforts, making the process more challenging and less efficient. Therefore, mastering the skill of selecting and applying suitable representations is crucial in supporting students' success in mathematics learning.

Previous studies have highlighted that students' mathematical representation abilities remain relatively low, particularly in the context of statistical topics (Ristiani & Maryati, 2022). Specifically, research has shown that students face challenges in mastering data representation, a key aspect of statistics, with their abilities often falling short of expected levels (Maria et al., 2022). These findings are further supported by studies conducted in junior high schools across different mathematical topics, which also reported similarly low levels of representation ability among students (Hijriani et al., 2018; Yanuarto, 2018; Amieny & Firmansyah, 2021).

Among the various topics in school mathematics, the topic of functions stands out as it extensively involves multiple forms of representation, including verbal, visual, and symbolic representations. These diverse representations are integral to understanding and working with functions. Therefore, this research aims to examine and describe students' mathematical representation abilities specifically in the context of functions and their inverses, providing insights into how students utilize and integrate these different forms of representation in their learning process.

RESEARCH METHODS

This research is classified as quantitative descriptive research. The term "quantitative" refers to the research method, indicating that the study uses numerical data to analyze and interpret the subject under investigation. Meanwhile, "descriptive" refers to the technique used for data analysis, where the goal is to describe and summarize the characteristics of the data rather than test hypotheses. Quantitative descriptive research, also referred to as descriptive statistics, combines these two elements—quantitative methods and descriptive analysis techniques—to provide a detailed and clear overview of the data being

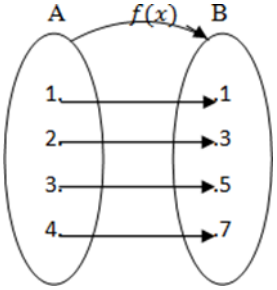
studied (Alfatih, 2022). In this approach, the researcher aims to capture and convey the patterns and trends present within the data.

The study was conducted on June 10, 2023, with a focus on a group of 15 seventh-grade students from a senior high school in Sungai Penuh, Jambi, who were enrolled in the mathematics and science majors. The population for this study consisted of all 15 students, and the total sampling technique was applied to select the sample. This means that every member of the population was included in the study, ensuring that all students participated in the research. By using this sampling method, the study aimed to gather comprehensive data on the students' mathematical representation abilities, specifically in the context of functions and their inverses.

The instrument used in this study was a mathematical representation ability test, consisting of three descriptive questions related to the material of functions and their inverses. Each question was specifically designed to assess one indicator of mathematical representation ability. These questions were adapted from Mailiana (2014), which had already undergone validation. In the original study, there were six problems, with each problem containing two points representing different indicators of mathematical representation ability.

For this research, the researcher selected only three of the original problems. Each of these three questions represented one indicator of mathematical representation ability and was assigned one point. The questions used in this study were directly linked to the specific indicators, as shown in Table 1. This adaptation allowed for a focused examination of students' mathematical representation abilities in the context of functions and their inverses.

Table 1. Mathematical Representation Ability Test Problems

No.	Mathematical Representation Ability Test Questions	Indicator
1.	Given $X = \{a, b, c, d, e\}$. The functions f and g on X are defined as $f(x) = \{(a, c), (b, d), (c, a), (d, e), (e, b)\}$ and $g(x) = \{(a, b), (b, c), (c, d), (d, e), (e, a)\}$. Determine the arrow diagram of the composition of the function $(f \circ g)(x)$!	Visual Representation
2.	Pay attention to the arrow diagram of the function $f(x)$ below!  If $g(x) = x^2 - 4$. Determine the resulting region of $(f \circ g)(x)$ for $x = \{1, 2, 3, 4\}$!	Written Words or Text Representation
3.	Given $f(x) = \frac{(4x+7)}{(3x-5)} \neq \frac{5}{3}$. Determine the value of $f^{-1}(x)$!	Mathematical Equation or Expression Representation

To gain an overview of students' mathematical representation abilities, the researchers scored the students' answers using a set of scoring guidelines that had been carefully prepared. These scores were then categorized into five levels of mathematical representation abilities: very high, high, medium, low, and very low. The categorization system used in this study was adapted from Aryanti et al. (2013), providing a structured framework to assess the varying levels of students' abilities in mathematical representation.

Table 2. Modified Mathematical Representation Ability Criteria

Category	Percentage (%)
Very High	≥ 90%
High	80% - 89%
Medium	65% - 79%
Low	55% - 64%
Very Low	< 55%

The collected data were analyzed by calculating the percentage of the total score relative to the maximum score, as outlined by Sarassanti (2021). This method allowed for a clear quantification of students' performance on the mathematical representation ability test, providing insights into their proficiency across the different indicators assessed.

RESULTS AND DISCUSSION

After the students completed the mathematical representation ability test, the researcher carefully examined their answers to evaluate their understanding and accuracy. Each test item was assessed systematically using a predetermined scoring rubric tailored to the mathematical representation ability test. The evaluation process aimed to ensure consistency and objectivity in scoring. The scores obtained from each student were subsequently compiled and analyzed to identify patterns and levels of mastery. This analysis was intended to provide a comprehensive description of students' mathematical representation abilities, particularly in understanding and applying concepts related to functions and their inverses. The results of the students' mathematical representation ability test can be seen in Table 3.

Table 3. Descriptive Data of Students' Mathematical Representation Ability

Number of Subjects	Maximum score	Minimum score	Average	Standard Deviation
15 students	7	0	4, 93	1,71

The researchers categorized students' mathematical representation abilities into five levels: very high, high, medium, low, and very low. The percentage results for each of these categories—very high, high, medium, low, and very low—are presented in Table 4, providing a detailed breakdown of students' performance in terms of their mathematical representation abilities.

Table 4. Students' Mathematical Representation Ability in Each Criteria

Category	Number of Subjects	Subject Code (Percentage)
Very High	None	-
High	None	-
Medium	3 students	S5, S7, S8 (77,78%)
Low	10 students	S1, S2, S3, S4, S6, S10, S12, S13, S14, S15 (55,55%)
Very Low	2 students	S9 (0%), S11 (33,33%)

Very High Category

Based on the scores obtained by the students, none of the 15 students were classified in the very high category of representation ability. This was due to their inability to create picture diagrams accurately, formulate equations or mathematical expressions correctly to solve mathematical problems, and present their solutions effectively using written text. These shortcomings in mathematical representation abilities prevented them from achieving the highest level of proficiency in the assessment. Additionally, the students struggled to demonstrate the level of understanding and skill required for more complex tasks, reflecting a gap in their overall mathematical representation capabilities.

If students' mathematical representation abilities were higher, it could significantly contribute to the development of their logical, rational, critical, and creative thinking skills. A stronger foundation in mathematical representation

allows students to engage more deeply with mathematical problems, facilitating more effective problem-solving and reasoning. This is in line with the findings of Mahendra et al. (2019), who highlighted that the ability to represent mathematical ideas is instrumental in fostering logical, rational, systematic, critical, and creative thinking. By enhancing these skills, students would not only improve their mathematical proficiency but also strengthen their cognitive abilities, better preparing them for both academic challenges and real-world problem-solving.

High Category

Based on the scores obtained by the students, none of the 15 students were categorized in the high level of representation ability. This was due to their inability to create picture diagrams accurately, formulate equations or mathematical expressions correctly to solve mathematical problems, and present their solutions effectively using written text. These limitations in mathematical representation abilities indicated that the students were not yet able to demonstrate the full range of skills required for higher-level proficiency in mathematical representation.

Students who possess high mathematical representation ability are typically able to effectively demonstrate all three key indicators of mathematical representation—creating accurate diagrams, formulating correct mathematical expressions, and providing well-structured written solutions. As highlighted by Ramanisa et al. (2020), students with high representation ability can successfully utilize these indicators to solve problems more effectively, showcasing a deep understanding of the material. Therefore, the lack of proficiency in these areas among the students in this study suggests that there is room for improvement in their overall mathematical representation skills.

Medium Category

Based on the scores obtained by students, three students—S5, S7, and S8—were classified in the medium category, with a percentage of 77.77%. These students were able to create picture diagrams, but their diagrams were incorrect. Additionally, they could formulate equations or mathematical expressions to solve

mathematical problems, but these solutions were incomplete or incorrect. Furthermore, they were not able to provide answers effectively using written text. Students in the medium category of representation ability have not yet developed strong skills in visual representation or in representing ideas using written text.

This aligns with research by Fitrianingrum & Basir (2020), which found that students in the medium category typically exhibit weaker abilities in creating accurate picture representations compared to their skills in other types of mathematical representation, such as symbolic or verbal representations. This suggests that while these students are capable of some forms of representation, they still struggle to produce complete and correct diagrams or articulate their reasoning in written form, highlighting areas for further improvement in their mathematical representation abilities.

Low Category

Based on the scores obtained by students, 10 out of the 15 students were classified in the low category of mathematical representation ability. This classification is due to the fact that these students were able to create diagrams, but they were incorrect; they could formulate equations or mathematical expressions to solve problems, but these solutions were incomplete or incorrect. Additionally, these students were not able to provide accurate answers in written text. As a result, their overall mathematical representation abilities were considered low.

According to Saputri & Izzati (2023), students in the low category are typically only able to fulfill one of the mathematical representation indicators, specifically verbal representation. These students struggle to meet the requirements for visual and symbolic representation because they are unable to solve problems involving graphs and mathematical equations. Consequently, these students often fail to provide adequate answers to the questions posed, highlighting significant gaps in their ability to represent mathematical concepts across different forms. This suggests a need for targeted instructional strategies to strengthen these students' representation skills, particularly in visual and symbolic domains.

Very Low Category

Based on the scores obtained by students, two out of the 15 students were classified in the very low category. This classification was due to the fact that these students either provided incorrect answers or, in some cases, did not answer the questions at all. Their responses indicated significant challenges in demonstrating mathematical representation abilities.

In line with the research by Ramadhana et al. (2022), students in the very low category have not yet developed the ability to create visual representations of mathematical problems, formulate equations or mathematical models based on the given problems or information, or clearly write down the steps to solve the problems in words. These students face substantial difficulties in representing mathematical concepts in multiple forms, which significantly hinders their ability to engage with and solve mathematical problems effectively. This suggests that targeted interventions are necessary to help these students improve their fundamental representation skills.

CONCLUSION

Based on the results of this study, it can be concluded that the average mathematical representation ability of students is still relatively low. This highlights a need for targeted strategies in teaching to improve students' skills in creating visual diagrams, formulating mathematical equations, and providing clear, written explanations of their problem-solving steps. For future research, it is recommended to explore effective teaching interventions that can enhance students' mathematical representation abilities, particularly focusing on visual and symbolic representations. Additionally, further studies could investigate the role of interactive tools or technology in supporting students' development of mathematical representations. It would also be valuable to examine the long-term impact of improving mathematical representation abilities on students' overall mathematical problem-solving skills. Finally, research could expand to include a larger sample size across different grade levels to provide a more comprehensive

understanding of the development of mathematical representation abilities over time.

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