INTERNATIONAL CONFERENCE ON EDUCATION AND SCIENCE (CICES)

ANALYSIS OF STUDENTS' MATHEMATICAL REPRESENTATION ABILITIES USING FORMATIVE ASSESSMENTS

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Abstract

Mathematics learning at the junior high school level faces the challenge of low mathematical representation skills of students. The use of formative assessment as a tool to identify aspects of representation has not been optimally utilized. This research is important to provide a contextual and responsive approach to learning diagnosis. This study aims to identify students' mathematical representation abilities through formative assessments on set materials. The qualitative descriptive approach was carried out by giving essay tests and interviews to 30 junior high school students. The analysis was carried out based on three indicators: image representation, symbols, and verbal. The validity and reliability of the instrument are guaranteed through item feasibility testing. As many as 77% of students were in the medium category and were able to represent questions in the form of pictures. Meanwhile, only 10% are able to present it completely in the form of pictures and words. The remaining 13% were in the low category and failed to meet the symbolic and verbal indicators. This pattern shows the dominance of visual representation, but the weakness of students' symbolic and verbal abilities. Formative assessments are able to map in detail the strengths and weaknesses of individual students and provide a basis for learning interventions. These findings confirm the effectiveness of formative assessments in identifying representational abilities. Further research needs to develop digital assessments and cross-level exploration.
Keywords: mathematical representation, formative assessment, visual indicators, symbolic ability, junior high school education

INTRODUCTION

Mathematical representations have a very important role in learning mathematics (Ippoliti, 2022; Mainali, 2020; Putra et al., 2023). According to National Council of Teachers of Mathematics (NCTM), The ability to represent mathematical ideas is indispensable because it can help students in solving mathematical problems (Mora et al., 2023; Ünal et al., 2023). (Cao et al., 2022; Finesilver, 2022) states that mathematical representation skills help students to understand mathematical concepts in the form of pictures, symbols, and words. Therefore, it can be concluded that students need to develop representational skills to understand mathematical concepts in these various forms (Taofik & Juandi, 2022; Torres et al., 2020).

(Stefanovski et al., 2021; Tan et al., 2022) reveals that representational abilities allow students to convey mathematical ideas or ideas in a certain way. By representing

mathematical ideas, students can find solutions to the problems at hand (Zhang et al., 2023). These ideas can be represented in a variety of ways, such as images, graphs, tables, symbols, and other forms of representation (Fattah et al., 2018; Kilmer et al., 2021). Therefore, mathematical representation skills are key in helping students solve mathematical problems using various methods such as pictures, graphs, and symbols (Cartwright, 2023; Jablonski, 2023).

The ability of mathematical representation can be seen from the achievement of the indicators (McCaul et al., 2023; Saputra et al., 2022). Indicators of mathematical representation ability include image, symbol, and verbal representations (Villegas et al., 2009). According to (Hwang et al., 2007) Indicators of mathematical representation ability include: 1) presenting mathematical problems in the form of images; 2) presenting mathematical problems in mathematical equations; and 3) presenting mathematical problems in written words. This study refers to these indicators. Specifically, these indicators are used in the learning of set materials, which often involve story problems that require visual representations to help students solve them (Ioos et al., 2020).

Although mathematical representations are important, the truth is that there are still many students who have difficulty in this regard. Based on interviews with mathematics teachers, it was found that many students had difficulty in representing a picture of a set of given problems and often made mistakes in writing mathematical formulas. Research (Cai & Fan, 2024; Croft, 2022) shows that students' mathematical representation skills are still relatively low, with common mistakes such as: 1) students are not able to present images based on the given problems; 2) students have not been able to write mathematical symbols correctly; and 3) students use illogical sentences when solving math problems.

The importance of mathematical representation skills needs to be understood by teachers, as these skills help students find ways to solve more complex math problems (Ochkov et al., 2022; Yusriyah & Noordyana, 2021). Therefore, representation must be more emphasized in the mathematics learning process in schools. One way that teachers can do to find out students' mathematical representation abilities is to provide assessments.

Assessment is an important part of learning activities carried out by teachers to obtain information about the development of students' learning competencies (Suwandi, 2023; Yangambi, 2024). Assessments are used to measure the achievement of student competencies in the learning process (Jannah & Widyanti, 2024), and provide information about students' strengths and weaknesses (Djamalovna, 2024; Kusairi, 2012). and provide information about students' strengths and weaknesses.

Formative assessments, conducted during the learning process, provide direct feedback on the progress of student learning outcomes (Sari, 2023). (Kemendikbud & Abduh, 2019) mentioned that formative assessments are used to obtain information related to the mastery of student competencies in certain learning units. The results of formative assessments can be used as a reference to plan the next learning. Therefore,. Formative assessments are important for teachers to use to determine students' mathematical representation skills (Ukobizaba & Byukusenge, 2023)

Research on the ability of mathematical representation using assessments has been carried out extensively. However, most previous studies (Permata et al., 2017) more focused on the use of diagnostic assessments. This research has a novelty by focusing on the use of formative assessments to measure students' mathematical representation abilities, which are still rarely studied. This research aims to fill this gap and provide new insights into how formative assessments can be used to assess students' mathematical representation abilities.

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This research is particularly important because an understanding of students' mathematical representation abilities allows teachers to tailor their teaching strategies (Nisa & Zaenal, 2023). With a focus on formative assessments, this study provides practical insights for teachers to tailor their teaching methods according to the needs of students identified directly through assessment. Given the many challenges faced by students in mastering mathematical representations, this research has the potential to improve student learning outcomes in mathematics learning.

METHOD

This study uses a qualitative approach of descriptive methods with the aim of describing students' representation abilities using formative assessment. The research was conducted at one of the junior high schools in Cirebon Regency. The subjects in this study were 30 students. The instruments used in this study were in the form of tests and interviews. The test instruments used have differentiation, difficulty, validity, and reliability indices that meet the criteria and are in accordance with the indicators of mathematical representation ability. Each test question item represents a representation indicator, such as an indicator presenting mathematical problems in the form of pictures (aspect of image representation) in question number 1, an indicator presenting mathematical problems into mathematical equations (symbol representation aspects) in question number 2, and indicators presenting mathematical problems into written words (verbal representation aspects) in question number 3. The data collection technique is used through interviews and the provision of formative assessments in the form of mathematical representation ability tests on set materials consisting of 3 essay questions. Data analysis techniques are carried out by collecting data, reducing data, presenting data, and drawing conclusions.

The data of student test results is processed by giving a score to the student's answer. Test result scores are analyzed to determine the category of the student's level of representation ability. The determination of the category is carried out by categorization according to(Arikunto et al., 2023) based on their average value and standard deviation.

Table 1. Categorization of Mathematical Representation Ability Level

Category	Interval
high	$skor \geq (\underline{x} + s)$
medium	$(\underline{x} - s) < skor < (\underline{x} + s)$
Low	$skor \leq (\underline{x} - s)$

Data analysis was carried out after the category of students' mathematical representation ability level based on indicators of mathematical representation ability (Hwang et al., 2007).

RESULTS AND DISCUSSION

The results of the students' mathematical representation ability test are presented in the following table of descriptive statistical results.

Table 2. Descriptive Statistics Student Mathematical Representation Ability Test

	N	Minimum Score	Maximum Score	Average	Standard Deviation
Ability Value Mathematical Representation	30	38	77,24	58	19,738

Based on Table 2, the average score obtained by students is 58 while the school KKM score is 75. The average score does not reach the school KKM score, but there are students who have a score of more than 75, meaning that some students have been able to solve mathematical representation problems while some other students have not been able to solve representation problems correctly. A description of the percentage of students' mathematical representation abilities can be seen in the following table.

Table 3. Categorization of Students' Mathematical Representation Ability Level

Category	Interval	Number of Students	Percentage
high	$skor \geq 77{,}24$	3	10%
medium	$38 < skor < 77{,}24$	23	77%
Low	$skor \leq 38$	4	13%
Total		30	100%

Based on Table 3, the test results were dominated by students with a moderate mathematical representation category of 77%. This means that most students still cannot meet every indicator of mathematical representation ability. In line with the results of the research (Putri & Munandar, 2020) stated that the cause of students being in the category of moderate mathematical representation is because every indicator of mathematical representation by students has not been fulfilled.

The results of the assessment in the form of tests carried out by students were analyzed to find out the strengths and weaknesses of students in working on mathematical representation skills problems. The results of the analysis are used as reference material for teachers to improve or improve students' representation skills. The researcher analyzed the answers of students in the high, medium, and low categories on each indicator. The analysis was carried out on three students because it was considered to be representative of the population. To make it easier for researchers to analyze data, researchers gave S1 codes to high-category students, S2 to medium-category students, and S3 to low-category students. In each representation indicator, the researcher also assigned a code R1 for the aspect of image representation, R2 for verbal representation, and R3 for symbol representation.

Students with High Mathematical Representation Ability Category

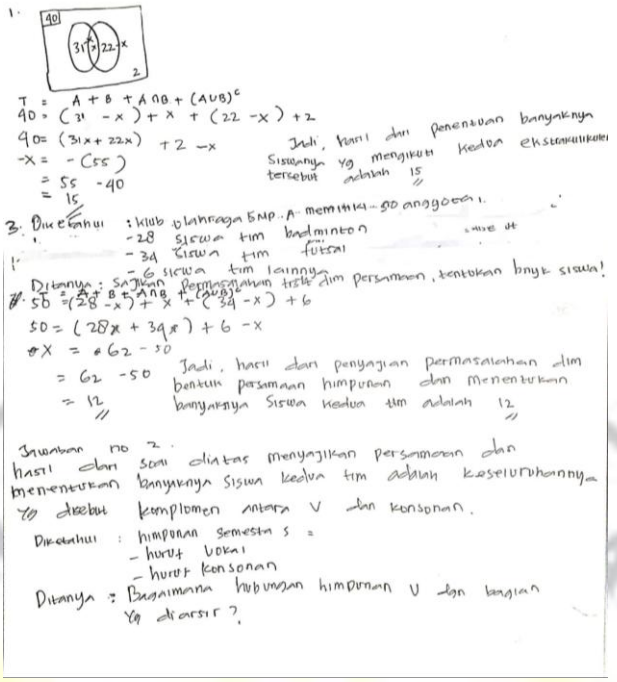

Figure 1. Answers for S1 Students

Based on Figure 1, S1 can present the image correctly and perform the completion steps correctly so that the resulting answers are correct. Thus, it can be said that S1 meets the R1 indicator. S1 can answer question number 2 correctly, namely S1 mentions that there is a complement between V (V set) and consonant (consonant letter set). Thus, it can be said that S1 meets the R2 indicator. In question number 3, S1 can write down the formula from the set but S1 is wrong in determining the final result. Thus, it can be said that S1 has not met the R3 indicator.

The following is a snippet of the interview with S1:

Researchers : "How do you present a set image with these numbers in question number 1?"

Student :" First, I write down what is known and what is asked in the question. In the problem, the number of students is 40, which means that it is the set of the universe. For example, students who participate in basketball as group A and who participate in volleyball as group B. Then, these 2 students mean that they are outside group A and B because they do not follow both. Because the likes of both are unknown, so I suppose as x. Furthermore, the sets A and B are subtracted by x. After I calculated, the x value was 15."

Researchers : "Why you answer the relationship between the V set and the shaded part is complement?"

Student : "Because this shaded part is a collection of consonant letters and must exist outside of the set V, because the set V is a collection of vowels, so the designation is complement."

Researchers : "Pay attention to your answer to question number 3. Do you think there is a mistake?"

Student : “"Yes, ma'am. I made a mistake in doing the calculation even though the formula used was correct.”

Based on the results of the interview above, S1 understands how to solve problem number 1. S1 can also explain the answers and completion steps in detail and precisely. So it can be concluded that S1 meets the R1 indicator. In question number 2, S1 was able to explain what was asked in the question correctly so that it can be said that S1 meets the R2 indicator. In question number 3, S1 can write down the set formula and realize his mistakes in solving the problem so that it can be said that S1 has not met the R3 indicator.

Based on the analysis of the questions and interview snippets above, students with the category of high mathematical representation ability can meet the image representation indicators completely and verbally correctly according to the problems presented. (Suryadi & Simanjuntak, 2022) stating that students in the category of high mathematical representation fulfill image and verbal representation well if students can present pictures and write down mathematical problems with words or written text. However, students have not met the symbol representation indicator because even though they write down mathematical formulas correctly, students are still wrong when determining the final result. According to (Huda, 2019) Students are not able to construct problems into the form of symbols, usually because students are not thorough in finding solutions to problems even though students are skilled in making equations.

Students with Medium Mathematical Representation Ability Category

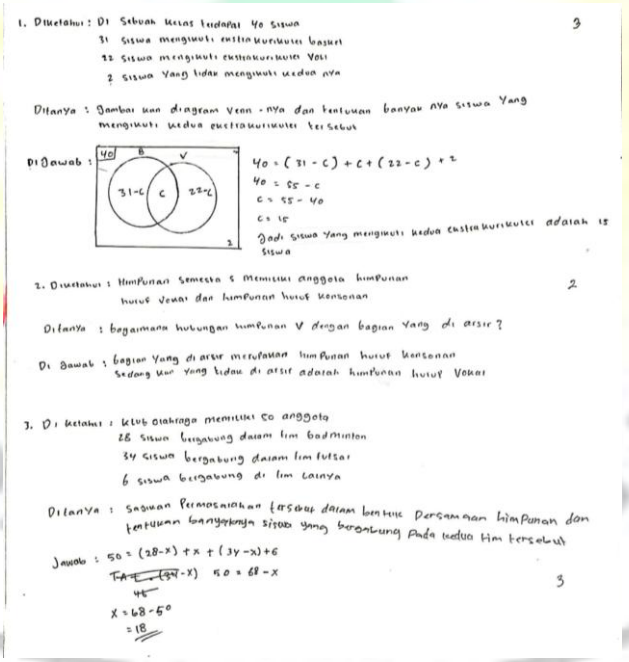

Figure 2. S2 Student Answers

Based on the test results above, S2 can present images according to the problems presented even with different interpretations. Thus, it can be said that S2 meets the R1 indicator. In question number 2, S2 gave an inappropriate answer because S2 did not give a final conclusion about the relationship between the V set and the shaded part. Thus, it can be concluded that S2 has not met the R2 indicator. In question number 3, S2 gave the correct answer but did not write down the formula of the set. Thus, S3 has not met the R3 indicator.

The following is a snippet of the interview with S2:

Researchers : “Can you explain why your number 1 answer is that way?”

Student : “Initially, I first assumed that the students who participated in basketball as a group of B and participated in volleyball as a group of V. These 40 students were the universal group, while the 2 students were outside both groups B and V because they did not follow both. Then I assume the students who follow both as c. Once c is known, I just need to reduce the number of students in sets B and V by c.”

Researchers : “In question number 2, you have not mentioned the relationship between the V set and the shaded part. What do you think the relationship has?”

Student : “I forgot what her name is. So I deliberately didn't write it down because I forgot.”

Researchers : “In question number 3, why don't you include the formula?”

Student : “I also forgot what the formula was so I didn't write it down.”

Based on the results of the interview above, S2 can explain the answers and completion steps in detail and precisely. So, it can be concluded that S2 meets the R1 indicator. In question number 2, S2 has not been able to explain the relationship between the V set, which is a set of vowels and a set of consonant letters, so it can be said that S2 has not met the R2 indicator. In question number 3, S2 did not write down the set formula so it can be said that S2 has not met the R3 indicator.

Based on the analysis of the questions and interview snippets above, students with the category of moderate mathematical representation ability can meet the image representation indicators appropriately. Students meet the indicators of image representation marked with students presenting images to solve problems correctly. However, students have not met the indicators of verbal representation ability because they do not fully explain the results of the relationship of the set and the shaded section. According to (Huda, 2019), Students who have not met verbal representation are characterized by students who have not been able to make conclusions based on the given problem. Students also did not meet the indicator of symbol representation ability because they did not write down mathematical formulas. (Leuly, 2020) mentioning that the symbol representation indicator has not been met if students have not been able to write mathematical formulas or symbols correctly.

Students with Low Mathematical Representation Ability Category

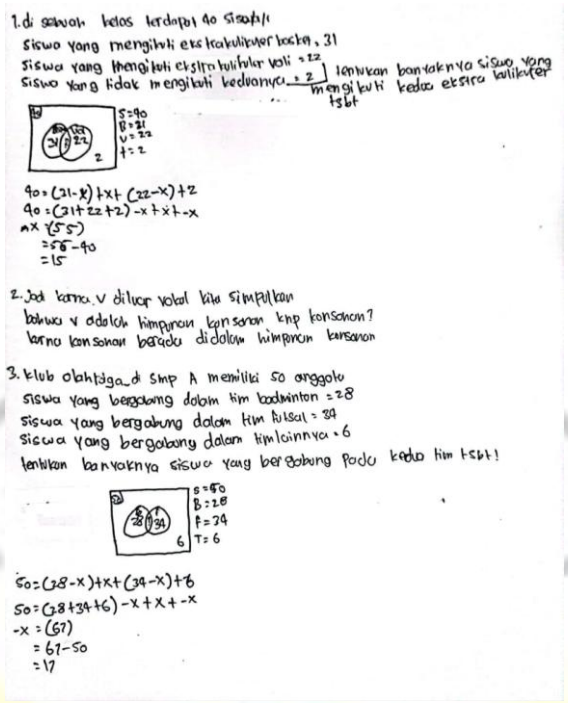

Figure 3. Answers for S3 Students

Based on the test results above, it can be seen that S3 has not been able to present the image correctly, so it can be said that S3 has not met the R1 indicator. In the second question, students presented an illogical answer so that the answer given was not correct. So it can be said that S3 has not met the R2 indicator. In the third question, students do not present mathematical formulas or symbols and the resulting answers are incorrect. So it can be said that S3 has not met the R3 indicator.

The following is a snippet of the interview with S3:

Researchers : "Can you tell us how you got the picture at number 1?"

Student : "I write down what is known and asked about the question first, then I put the known numbers into the set picture."

Researchers : "Is the number of student groups that participate in basketball and volleyball only true?"

Student : "That's right, Ma as is known in the question."

Researchers "Can you explain answer number 2?"

Student :" The V set is outside, ma'am, so the V set is a collection of consonant letters."

Researchers : "Try to re-read question number 2."

Student : "In the question there is a sentence that the set that is not shaded is a set of vowels (set V), it means that I am wrong, ma'am.."

Peneliti : "In question number 3, why don't you include the formula and whether the answer you gave is correct?"

Siswa : "I forgot what the formula was and I think my answer was correct."

Based on the results of the interview above, S3 looks confident in his answer even though the answer is actually wrong. It should be to know that students who participate in basketball or volleyball alone should be reduced by students who participate in both. So it can be concluded that S3 has not met the R1 indicator. In question number 2, S3 did not read the questions carefully so that the answers presented were wrong. Therefore, it can be said that S3 has not met the R2 indicator. In question number 3, S3 did not write down the set formula and did not realize his mistake in solving the problem. So it can be said that S3 has not met the R3 indicator.

Based on the analysis of the questions and interview snippets above, students with low mathematical representation ability categories have not met all indicators of mathematical representation ability. (Suryadi & Simanjuntak, 2022) reveals that if students do not present images, symbols, and make conclusions correctly then students can be said to have not met all three indicators of mathematical representation.

Based on the results of the three analyses above, students who can present mathematical problems in the form of pictures are students with high and medium representation ability categories. Students who can present math problems into written words are high-category students and no students can present math problems into mathematical equations.

The results of the tests conducted by students can help teachers in providing feedback in the form of evaluations or improvements to improve students' abilities. The assessments provided can help teachers to identify students' learning needs so that teachers can improve learning in the next meeting. Based on the test results, it was concluded that most students did not write down mathematical formulas related to sets. Therefore, in learning, teachers should be able to provide reinforcement first so that students remind themselves of the set formula. Teachers need to provide assessments that can help students to remember the formula of the set. Another weakness of students is that students cannot present mathematical problems into written words. Most students have difficulty representing the images in the question into verbal form. The teacher can give directions to read slowly and carefully so that students can find the right conclusion. Teachers also need to reintroduce the concept of complementarity to students. In addition, teachers can provide assessments in the form of practice questions to train students' thinking skills.

CONCLUSION

This study succeeded in revealing the profile of the mathematical representation ability of junior high school students through the application of structured formative assessment. Answering the research questions, the findings showed that the majority of students were in the medium category, with a strong tendency to meet the indicators of image representation, but weak in the symbolic and verbal aspects. The use of formative assessments has been shown to be effective in identifying students' strengths and weaknesses individually, as well as providing meaningful feedback. The main contribution of this research is the application of formative assessment as an approach that has not been widely explored in the context of mathematical representation. In practical terms, these results provide a reflective framework for teachers to design responsive and data-driven teaching strategies. This study emphasizes the importance of formative assessment in improving the quality of mathematics learning based on representational understanding.

Despite limitations in the school context and the limited number of subjects, future research can expand the scope of the population and test the effectiveness of formative assessments across topics and levels of education. In addition, it is necessary to develop technology-based assessment instruments to improve the accuracy and efficiency of the analysis.

Practitioners are advised to use the results of the assessment to develop a targeted pedagogical intervention through systematic remedies and reinforcement of concepts. Policymakers need to encourage the integration of formative assessments in the curriculum as a tool for continuous learning diagnosis. Teachers and principals should facilitate specialized training on formative assessments and mathematical representations. Researchers can further explore the relationship between mathematical representations and students' metacognitive abilities. It's time for assessments to not only be a measuring tool, but also a key strategy for transformative learning.

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