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Examining Mathematical Communication Ability in Geometric Transformation: An Analysis of Student Test Results

Firza Mufti Aulia, Hasanuddin, Abdur Rahman Hakim

Mathematics Education, Faculty of Tarbiyah and Keguruan, Sultan Syarif Kasim Riau State Islamic University, H. R. Soebrantas Street, KM. 15.5, Simpangbaru, Tampan, Pekanbaru, Indonesia. Postal code: 28293

*Corresponding Author e-mail: hasanuddin@uin-suska.ac.id

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Abstract

The purpose of this research is to analyze students' mathematical communication ability (MCA) through test questions on geometry transformation material that contains MCA indicators. This research uses a descriptive quantitative approach, by measuring the validity of the questions, then giving test questions to students, calculating student scores, and grouping them by category, and analyzing student answers. The research was conducted at a senior high school in Indragiri Hilir, the research sample was class 12 students majoring in mathematics and science as many as 20 people, with the assessment method and research instruments namely open description questions. The test questions given have been tested for validity using the Aiken index, and are in accordance with the MCA indicators set. The results of the study based on student test scores obtained 20% of high category students, 65% of medium category students, and 15% of low category students in solving MCA test questions. From the results of this study, it is necessary to strengthen learning to facilitate students' MCA.

Keywords: Geometric Transformation; Mathematical Communication Skills; Quantitative Analysis Test Results .

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INTRODUCTION

Mathematical ability is the capacity or skills of a person (student) to solve mathematical problems (Isro'il & Supriyanto, 2020). In general, the mathematical ability of each student is different because the characters of the students are diverse. Students' mathematical abilities can be grouped based on their levels, such as high, medium, and low. According to NCTM experts, there are 5 standards of initial mathematical ability, namely mathematical problem reasoning ability, mathematical communication ability, mathematical solution ability, mathematical representation ability, and mathematical connection ability (Sintawati & Mardati, 2023). In this article, the author will discuss mathematical communication ability (MCA). MCA is

important for students to have and influences the learning process in class (Lubis et al., 2023). MCA is the ability of a person (student) to present work in mathematics in various representations, such as pictures or diagrams, algebra, tables, equations, and symbols to find solutions and contain appropriate relationships both orally and in writing (Ernawati et al., 2021; Minarni et al., 2020; Suhenda & Munandar, 2023). Therefore, MCA plays an important role for students to express ideas when solving math problems.

The importance of MCA has been emphasized in many studies. Even so, many studies show results that are not as expected, because students do not have good MCA. This is because students do not understand the basic concepts of mathematical calculations, want to finish quickly, do not understand the meaning of the problem, forget to write known, asked, and conclusions, and are not careful in solving problems (Jufri et al., 2021; Ramadhan & Minarti, 2018; Wahid & Marlina, 2022). Other previous studies have also shown that students' MCA is at a very low level. This condition is shown by the recapitulation of student answers as many as 76% of students with incorrect or incomplete answers and as many as 65% of students are in a very low ability category based on the score conversion results (Sriwahyuni et al., 2019). Furthermore, students' lack of effort in working on the problems given, haste and lack of thoroughness in working on geometry transformation material (Maulani & Zanthy, 2020). In addition, students' low MCA is also seen in(Hasanah et al., 2024; Nurapni & Kurniawati, 2021; Putri et al., 2022; Ulymaz et al., 2022).

Some of these previous studies show that students' MCA when solving mathematical problems is still relatively low. However, there are also those who show positive student KKM results, good student understanding and interest in explaining ideas, solving problems and modeling. This is shown in the KKM of students who are at a medium to very high level in exponential material (Anderha & Maskar, 2020), and SPLDV material (Sarumaha et al., 2022). Therefore, as a renewal, the discussion of this article is about student SMI with a focus on transformation geometry material, because this material is one of the materials that contains understanding of algebra, graphics and modeling mathematics in accordance with the MCA indicators. This research was conducted, to answer the research problem regarding students' mathematical communication skills in solving problems on geometry transformation material.

To measure students' MCA, it is essential to first establish the indicators that will guide the assessment. There are several indicators of student MCA that can be used as guidelines for student abilities. The MCA indicators are: (1) Connecting real objects, images, and diagrams into mathematical ideas, (2) Explaining mathematical ideas, situations, and relationships with images, graphs, or algebra, (3) Expressing everyday events in mathematical language, (4) Listening, discussing, and writing about mathematics, (5) Reading with understanding a written mathematical presentation, (6) Formulating mathematical questions relevant to the problem situation, and (7) Making conjectures, compiling arguments, formulating definitions, and generalizations (Lestari & Yudhanegara, 2018). The evaluation standards for measuring MCA in this study are several written indicators including: (1) Expressing everyday events in mathematical language, (2) Explaining mathematical ideas,

situations, and relationships with images, graphs, or algebra, (3) Connecting real objects, images, and diagrams into mathematical ideas.

The purpose of this study was to analyze students' MCA through test questions on geometric transformation material. Therefore, the author has made and tested the MCA test instrument in the form of test questions that have been tested for validity. So that in this article, the results of student answers will be analyzed to determine and measure student MCA based on student acquisition scores. This article consists of four parts, namely, reviewing the theories that support the topic and research problem, discussing the research methodology carried out, the results and discussion of the findings during the research conducted, and finally the conclusions and recommendations for future research.

METHOD

The approach used is a descriptive quantitative approach, generally carried out to determine the level of a variable in a population or sample (Ali et al., 2022). The research was conducted at one of the SMAN in Indragiri Hilir, with the research population being 12th grade students and the research sample was 12th grade students majoring in mathematics and science as many as 20 people selected by purposive sampling because students are difficult to choose randomly. The test technique and research instruments are descriptive test questions with three questions (with the third question having two sub-problems) on geometric transformation material that matches the students' MCA indicators. The test given has met the valid criteria by the validator using the calculation of the Aiken index. The research data were collected based on the MCA test scoring rubric data and the results of student test questions. After the data is collected, it will be grouped based on the specified criteria and continued with descriptive analysis of student answers. The test questions were assessed based on the MCA test scoring rubric in the following Table 1.

Table 1. The MCA Test Scoring Rubric

Indicators	Response	Score
Expressing everyday events in mathematical language	Blank answer.	0
	There is an answer, but it does not meet the criteria.	1
	The answer is correct, but the process does not meet the criteria.	2
	The answer is correct, meets the criteria but there are minor errors.	3
	Correct answer, able to express everyday events in mathematical language.	4
Explaining mathematical ideas, situations, and relationships with images, graphs, or algebra	Blank answer.	0
	There is an answer, but it does not meet the criteria.	1
	The answer is correct, but the process does not meet the criteria.	2
	The answer is correct, meets the criteria but there are minor errors.	3
	Correct answer, able to explain mathematical ideas, situations, and relationships with images, graphs, or algebra	4
Connecting real objects, images, and diagrams into mathematical ideas	Blank answer.	0
	There is an answer, but it does not meet the criteria.	1
	The answer is correct, but the process does not meet the criteria.	2
	The answer is correct, meets the criteria but there are minor errors.	3
	Correct answer, able to connect real objects, images, and diagrams into mathematical ideas	4

Based on Table 1. item number 1 is assessed to measure the 1st indicator, item 2 is assessed to measure the 2nd indicator, and item 3 is assessed to measure the 3rd indicator. Furthermore, student scores are calculated based on the assessment guidelines with the formula:

$$\frac{Total\ score}{Total\ maximum\ score} \times 100$$

Furthermore, there are 3 categories of interpretation of student test scores, namely high, medium, and low. This interpretation refers to Subekti, et al in (Anggraeni & Widayanti, 2019) with calculations based on average values and standard deviations. as for the 3 categories of student test score results as in Table 2. following:

Table 2. Student Test Score Categories

Value Range	Category
$x \geq 89{,}23$	High
$48{,}27 < x < 89{,}23$	Medium
$x \leq 48{,}27$	Low

RESULTS AND DISCUSSION

The results of student tests after working on geometry transformation problems show a similar pattern between students with one another, namely the average student can work well on problem number 1 but has difficulty working on problem number 3b. The results of the acquisition of student scores after working on student MCA test questions on geometric transformation material are presented in Table 3. below.

Table 3. Student Score Acquisition Results

Student Code	Description Test Students				Score
	1	2	3a	3b	
S-1	2	2	4	0	50
S-2	3	4	2	1	62,5
S-3	4	4	4	2	87,5
S-4	4	2	2	2	62,5
S-5	4	4	2	2	75
S-6	4	4	4	1	81,25
S-7	4	4	4	0	75
S-8	4	4	2	2	75
S-9	4	4	4	3	93,75
S-10	4	4	4	2	87,5
S-11	4	4	4	3	93,75
S-12	4	2	1	0	43,75
S-13	4	3	0	0	43,75
S-14	4	3	1	1	56,25
S-15	4	4	4	3	93,75
S-16	4	4	2	2	75
S-17	4	3	1	0	50
S-18	4	0	0	0	25
S-19	4	2	1	1	50
S-20	4	4	4	3	93,75

Based on student scores in Table 3. there are 4 students in the high category, 13 students in the medium category and 3 students in the low category. This means, there are 20% of high category students, 65% of medium category students, and 15% of low category students in solving the MCA test questions. Furthermore, researchers randomly selected 3 subjects to be analyzed to represent each category of student scores as shown in Table 4 below.

Table 4. Student Representatives for Each Category

Student Code	Score	Category
S-9	93,75	High
S-8	75	Medium
S-13	43,75	Low

The selected research subjects were analyzed in accordance with the predetermined MCA indicators. The results of the researcher's analysis of student test results on geometry transformation material are described based on indicators on each test question number.

1. Sebuah taman berbentuk persegi terletak pada koordinat titik A(1,1), B(3,-2), C(6,0), D(4,3). Taman tersebut akan dipindahkan dari posisi awalnya sejauh (-3,2), lalu di putar sebesar 90° terhadap suatu pohon yang terletak pada titik O(0,0). Temukanlah posisi titik koordinat taman setelah dipindahkan!

Figure 1. Test Question Number 1

Test question number 1 in Figure 1. contains the 1st indicator. Problem number 1 can be solved well by students, as shown in Figure 2 below.

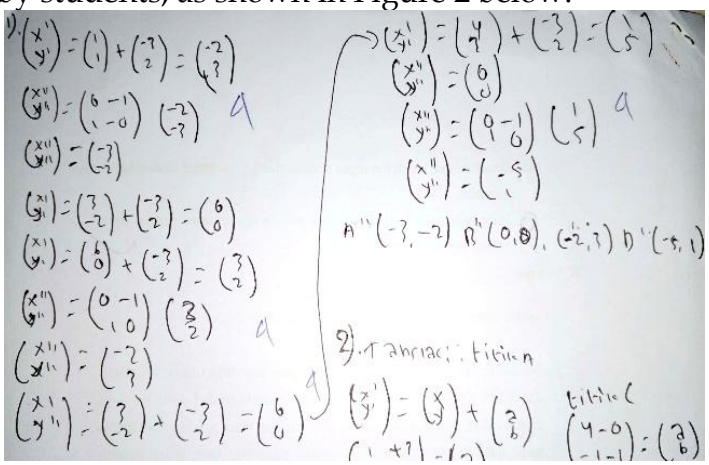

Figure 2. Answer of S-19 on Question Number 1

Subjects S-9, S-8, and S-13 were able to complete the answer complete with the formula and process until the appropriate solution was found. The three subjects have also done well to write the form of the mathematical model according to the situation given in the problem.

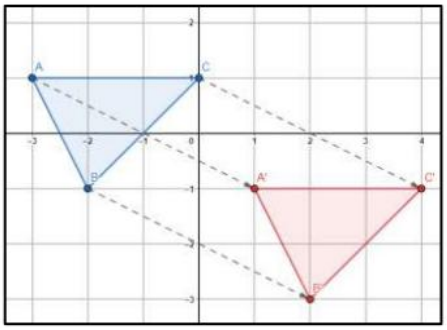

Figure 3. Test Question Number 2

Test question number 2 in Figure 3. contains the 2nd indicator. The majority of students have been able to solve the answer well. Subjects S-9 and S-8 have completed the answer well, have written the formula and mathematical process and can obtain a solution that matches the question. Meanwhile, subject S-13 was only able to write the final result, as shown in Figure 4 below.

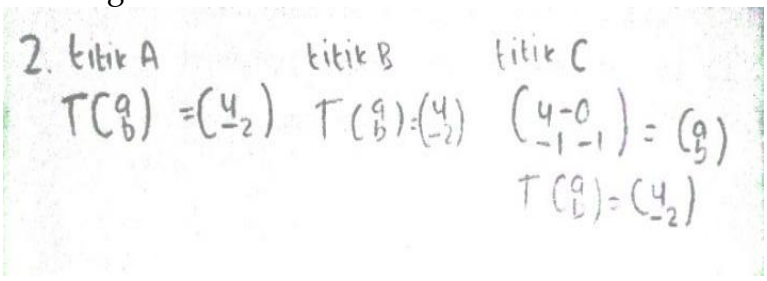

Figure 4. Answer of S-13 on Question Number 2

Although the final result was correct, the expected formula and process were not made by S-13. Unfortunately, the three subjects only showed and proved the type of transformation that occurred, but no explanation was given regarding the mathematical process that had been carried out. This is in line with the results of research by Maulani and Zanthy, which show that students lack effort in working on problems.

3. Diketahui sebuah garis AB dengan koordinat titik A(-2,0) dan B(1,2), akan di rotasikan sebesar 90° terhadap titik pusat O(0,0). Tentukanlah!
   a. Buatlah hasil bayangan titik A' dan B'.
   b. Jika bayangan garis $A'B'$ di refleksikan terhadap titik pusat O(0,0), maka buatlah garis $A''B''$ pada bidang koordinat kartesius.

Figure 5. Test Question Number 3

Test question number 3 in Figure 5. contains the 3rd indicator. In problem number 3, there were two sub-problems given, the majority of students only answered part a only, only a few students answered part b. Subject S-9 was able to complete the mathematical process needed to solve problems 3a and 3b well, but S-9 did not provide a graph or picture as instructed in problem 3b. Subject S-8 was able to find the correct final result, but the formula and process were not written down, and did not include a picture or graph in problem 3b, as shown in Figure 6 below.

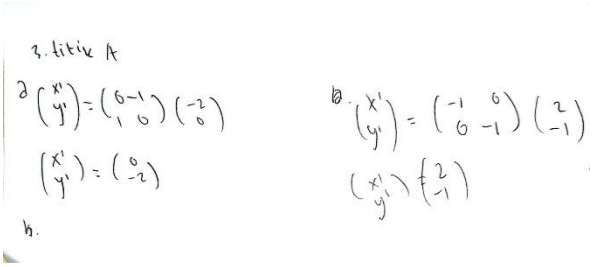

Figure 6. Answer of S-8 on Question Number 3

Furthermore, subject S-13 did not provide any answer for question number 3, only answering questions number 1 and 2. It can be seen that the subject has not been able to fulfill this indicator, even though he can write down the mathematical steps.

Of all the students' answers, no student has written what is known and asked in the answer. This is relevant to the results of research by Ramadhan and Minarti, who concluded that it was not considered important by students. In addition, students also do not include conclusions at the end of the answer, this is also shown in the research of Jufri et al.

CONCLUSION

MCA can be measured through test instruments that contain items according to MCA indicators. In this study, researchers have conducted tests to determine students' MCA on geometric transformation material and the results show that there are 20% of high category students, 65% of medium category students, and 15% of low category students in completing the MCA test questions. The conclusion of the analysis of the three subjects representing each category, as follows: High category subjects can fulfill the 1st and 2nd indicators, but less on the 3rd indicator. Moderate category subjects can fulfill the 1st indicator, but less on the 2nd and 3rd indicators. Low category subjects can fulfill the 1st indicator, but less on the 2nd indicator, and do not fulfill the 3rd indicator. The results of this study illustrate that MCA still needs to be improved, especially in the 2nd and 3rd indicators that have not been fully met by students. The need to develop differentiated learning strategies and test questions will help students understand more complex concepts, especially on indicators that show a high level of difficulty

RECOMMENDATION

Recommendations for future research include research to determine students' MCA with higher-order ability-based problems and according to the applicable curriculum. Interviews with students and teachers in related schools are also suggested to strengthen the results of the study to be able to provide in-depth insights into the factors that influence MCA or specific aspects of the teaching process that can be explored. Experimenting with a larger sample and different mathematics materials is also suggested for future research.

Author Contributions

Firza Mufti Aulia (FMA), Hasanuddin (H), and Abdur Rahman Hakim (ARH). "Introduction, methodology, results and discussion and conclusions, FMA; review-writing guidance, H; plagiarism checking, FMA and ARH; supervision, H.

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Conflict of interests

The authors declare no conflict of interest.

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