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STUDENTS' MATHEMATICAL COMMUNICATION SKILLS IN SOLVING STORY PROBLEMS BASED ON MATHEMATICAL ABILITIES

***Ilmus Samawati[1] and Rooselyna Ekawati[2]**
Mathematics Education of Universitas Negeri Surabaya
ilmus.17030174015@mhs.unesa.ac.id[1] and rooselynaekawati@unesa.ac.id[2]
*correspondence: ilmus.17030174015@mhs.unesa.ac.id[1]
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Abstract
The research aims to describe the students' mathematical communication skills in solving story problems based on mathematical abilities. This research is descriptive qualitative research. Subjects in this research involved 3 students tenth-grade science in one of the senior high schools in Sidoarjo. Based on the mathematics scores in the last report card, I obtained one student with high mathematical abilities, medium mathematical abilities, and low mathematical abilities. The research data were obtained from mathematical communication skills tests and interviews based on a communication skills test. The results showed that students' mathematical communication skills are in line with their ability to solve problems on story problems because they are influenced by the level of mathematical ability of each student who is different in written and oral communication skills.

Keywords: mathematical communication skills, problem-solving, story problems, mathematical abilities

Introduction

Communication is one of the important things in the learning process and can make learning come alive because communication is one of the goals that must be achieved in learning mathematics. With the statementSuhaedi (2012) communication plays the most important role because by communicating students can exchange ideas both among students themselves, with the teacher and the environment. The importance of communication in the process of learning mathematics includes sharing ideas and clarifying understanding orally and in writing so that it is clear, convincing, and appropriate in the use of mathematical language(NCTM, 2000). Prayitno, Suwarsono, dan Siswono (2013)argues that mathematical communication is needed to communicate ideas or solve mathematical problems, both orally, in writing, or visually, both in learning mathematics and learning mathematics outside. According toWardhana (2018), the mathematical communication of oral students is the process of delivering ideas or ideas in the form of one's speech. Someone is said to have spoken mathematical communication if they speak and involve mathematical content.

The written mathematical communication of students is the process of delivering

students' ideas in written form. Someone is said to have written mathematical communication if they present their ideas in writing. In communicating both orally and in writing it takes a tool and mathematics is that tool, in the opinion of Mundy, et al in (NCTM, 2000). This is reinforced by the statements of Baroody in (Pangastuti, Johan, & Kurniasari, 2014; Izwita, 2009; Nunun, 2012) that mathematics is a language or tool that can be used to communicate ideas or ideas, precisely, and concisely so that information can be conveyed.

In this research, researchers used problems with story problems in the form of descriptions because students still had difficulty in interpreting problems in the form of story problems into mathematical symbols or images and the story problems presented in the form of descriptions would make it easier to express mathematical communication skills, this was revealed byAnsari (2009). This proves that students still experience difficulties in the process of mathematical communication skills. Mathematical communication skills are important in learning mathematics because students who have good mathematical communication can easily interpret and solve a problem. This is consistent with research conducted by Choridah and Nurhasanah, which states that mathematical communication skills are very important to be raised so that students are actively involved in learning and eliminating the impression of mathematics is a difficult and frightening lesson(Choridah, 2013; Nurhasanah, 2019).

According to Ginsburg in Asmana (2018) states students must learn to write, read, and understand mathematical symbols if they want to be successful in solving mathematical problems. Polya in Asmana (2018) distinguishes problems into two types, namely: (1) problems to find; and (2) problems to prove. So in solving story problems, there is a relationship between the ability to solve problems with students' mathematical communication skills. This is reinforced by the opinion of Asmana (2018)which states that in general, there is a consistent linear correlation between understanding the problem of the problem-solving process and communication skills. In mathematics, problem-solving is also an important tool according toOzdemir and Reis (2013). Polya in Asmana (2018) said the steps of solving problems, namely: (1) understanding the problem (understanding the problem); (2) making a plan (devising a plan); (3) carrying out the plan (carrying out the plan); and (4) looking back. So, problem-solving is a process that students go through in solving a given problem by the steps of understanding the problem, making plans, carrying out plans, and checking again.

Every student has different mathematical communication skills so that the ability of communication and problem-solving abilities are thought to be different too. This is supported by a statement fromWardhana(2018), in each class, some students have different mathematical communication skills. This is influenced by many factors, such as the level of mathematical ability, communication skills, ability to express opinions, and self-confidence. Students with different mathematical abilities will have different ways of understanding problems in mathematics and also solving them. Through these differences, the teacher can investigate how far the mathematical understanding and location of the concept errors in students so that the need for classification of students' mathematical abilities. According toLutfiannisak and Sholihah(2018), mathematical communication skills can be classified based on students' mathematical abilities, namely the daily ability of students to follow the teaching and learning process. The mathematical abilities that will be used in this study are divided into three, namely high, medium, and low levels.

However, some researches that examine mathematical communication skills in solving story problems not using any review or using other reviews. Whereas in this study, this study aims to describe students' mathematical communication skills in solving story problems based on mathematical abilities so that researchers want to know whether the level of mathematical ability will affect students' mathematical communication skills in solving story problems?

This research is important for educators because it can be used as input in designing

appropriate learning so that these mathematical communication skills can help students to improve achievement and learning outcomes in class.

Method

In this research, the data were analyzed qualitatively with a descriptive approach. This research was conducted in April 2020 and involved 10th-grade students of science from senior high school in Sidoarjo, as many as 10 who were selected based on mathematics scores in their last report card. Of the 10 students, 3 students were selected with the highest, average, and lowest report card, regardless of gender.

Data were collected bygiving a written test containing several story problems and semi-structured interviews for each students. The material chosen was Three Variabel Linear Equation System because this material requires accuracy so it is not wrong in providing mathematical symbols. See the instrumen for this research in Figure 1.

Solve all the problems properly!

1. Bimo bought 3 packages of sweet soy sauce, 1 packet of soy sauce, and 2 packages of fish sauce, he paid Rp 20.000,00. Santi buys 1 packet of sweet soy sauce, 2 packages of salty soy sauce, and 1 packet of fish sauce, he has to pay Rp 12.500,00. Darmin bought 2 packages of sweet soy sauce, 1 package of soy sauce, and 2 packages of fish sauce he had to pay Rp 16.000,00. If Tamara buys 1 packet of sweet soy sauce 1 packet of soy sauce and 1 packet of fish sauce then he must pay ....
2. Ani, Nia, and Ina go together to the fruit shop. Ani bought 2 kg of apples, 2 kg of grapes, and 1 kg of oranges at Rp 67.000,00. Nia buys 3 kg of apples, 1 kg of grapes, and 1 kg of oranges for Rp 61.000,00. Ina bought 1 kg of apples, 3 kg of grapes, and 2 kg of oranges at Rp 80.000,00. The price of 1 kg of apples, 1 kg of grapes, and 4 kg of oranges are ....
3. At the "MURAH" bookstore Abid bought 4 books, 2 pens, and 3 pencils at the price of Rp 26.000,00. Farhan bought 3 books, 3 pens, and 1 pencil for Rp 21.500,00. Shifa bought 3 books and 1 pencil for Rp 12.500,00. If Ane buy 2 pens and 2 pencils, then he has to pay ....

Figure 1. Test Instrument

Table 1 describes the interview guidelines that guide the observer to collect data. This interview guideline is used to understand and confirm the oral communication process of the written tests they have done. This interview guideline is based on indicators of oral mathematical communication skills according toPuspa, Riyadi, & Subanti (2018), namely (1) expressing mathematical ideas; (2) interpret mathematical ideas (notations and symbols); and (3) evaluating mathematical ideas and solution. However, this guideline does not mean guiding the interviewer to use all question items too rigidly.

Table 1. Guideline for Interview

Indicator of mathematical communication skills	Example of item question
Understanding (express) problem	Do you understand the purpose of this story problem? Explain! What is the idea or concept of the problem? Do you understand every notation or symbol in the story problem? Explain!
Interpret problem	Do you have trouble finding a solution to the story problem? Can you explain about the solution?
Evaluate	Do you check back after getting an answer? Can you explain about the conclusion?

In addition to indicators of oral mathematical communication skills, there are also indicators of written communication skills that also adopted fromPuspa, Riyadi, & Subanti (2018). In analyzing student answer, scoring techniques were used for mathematical

communication skills test questions based on the assessment rubric made by Ramadhan & Minarti (2018)shown in Table 2.

Table 2. Item Scoring Guideline Test of Mathematical Communication Skills

Score	Mathematical Communication Skills
0	No answer
1	The answer is wrong but there is a reason
2	The answer is almost correct (the conclusion is not there or the formula is right but the conclusion is wrong or the answer is right the reason is wrong)
3	The correct answer with not complete reason or the answer is a little wrong
4	The answer is correct with correctly and clearly reason

To measure mathematical communication skills individually students use the following formula:

$$P = \frac{X}{Y} \text{ x } 100$$

Information:

P = Level of mathematical communication skills of each individual

X = Total score obtained by individuals

Y = Maximum score of each individual

Furthermore, the results of the percentage score of students' mathematical communication skills are categorized into very high, high, medium, low, very low categories. This category is converted by using a score conversion according to Nurkancana and Sunarta in (Arifani, Sunardi, & Setiawan, 2015).

Table 3. Score Conversion

Percantage	Category
$88 \leq P \leq 100$	Very high
$76 \leq P < 88$	High
$64 \leq P < 76$	Medium
$52 \leq P < 64$	Low
$P < 52$	Very low

Adopted to Polya in Asmana (2018) the indicators of mathematical problem-solving abilities in this research are (1) understanding problems (identifying problem); (2) devise a plan and carry out the plan; and (3) look back. Scoring to mathematical problem-solving ability given as in Table 4 by adopted the rubric fromWahyuningrum & Suryadi (2014)

Table 4. Item Scoring Guideline Test of Mathematical Problem-Solving Abilities

Score	Scale I Understanding	Scale II Plan	Scale III Look back
0	There is no attempt	There is no attempt	There is no attempt
1	Completely wrong to interpret the problem	Solution plan does not fit	Computational errors most of the solution is wrong, wrong answer.

2	Misinterpretation of most of the problems	Partially correct procedures with large error	Computational true, true answer
3	Misinterpretation of fraction problems	Substantially correct procedure with minor errors	-
4	Complete understanding of the problem	Complete understanding of the problem	-
Max Score	4	4	2

The analysis phase is carried out after obtaining data collection from written test data and interviews. The results of tests of mathematical communication skills and interviews were analyzed using indicators established by researchers. First, the results are analyzed using problem-solving indicators to find out how students solve story problems. Then it is re-analyzed using indicators of mathematical communication skills to find out which category the student is in. The stages in data analysis include data reduction, data display, and verification.

Findings and Discussion

Here, the following table categories the research subject based on the level of mathematical abilities:

Table 5. Level of Mathematical Abilities

Name	Category	Code
MR	High	ST
JA	Medium	SS
KP	Low	SR

Mathematics problem-solving abilities code PM, for scale 1 code PM1, scale 2 code PM2, and scale 3 code PM3. For mathematical communication abilities code KM. It also supported the students' interviews.

Student Work

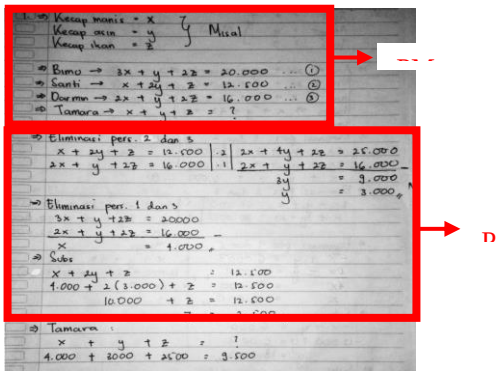

Figure 2. Answer ST in number 1

Based on Figure 2, it can be identified that ST understands the problem by writing things that are known and what is asked in PM1. ST also wrote the solution coherently and clearly seen in PM2. Furthermore, ST writes conclusions correctly using mathematical sentences, but SH does not explain clearly using their sentences. The ST conducts a double check but the ST does not write it down, so the ST answer is correct but the evaluation indicators are not fill in writing. This was also shown in the interview between researcher and ST. See the transcript of the interview in Figure 3.

R : Do you understand the purpose of this story problem?
ST: Yes, I do. The problem in number 1 is about 3 people who bought 3 different items. Then asked for the fourth person, Tamara, how much should she pay if she buys these items.

→ Understanding PM1

R : Do you have trouble finding a solution to the story problem?
ST: No, I don't have a trouble.
R : Nice. Can you explain about the solution?
ST: Sure. First, I eliminate equations 2 and 3 to get the value of y. Then, I eliminate equations 1 and 3 again to get the x value. After getting the values of x and y, I find the value of z by substituting the value in equation 1. So we get the values of x, y, and z, then substituted in Tamara's equation. The results obtained are 9.500.

→ Plan PM2

R : Do you check back after getting an answer?
SH: Yes, I do.
R : How do you do? Why didn't you write it down?
SH: Should it? Sorry.
R : It's okay. Then explain to me, please.
SH: I tried entering the values of x, y, and z in one equation, which is equation 1 and I found the same result.

→ Mathematical Communication

Figure 3. Interview about Understanding, Plan, and Mathematical Communication of ST

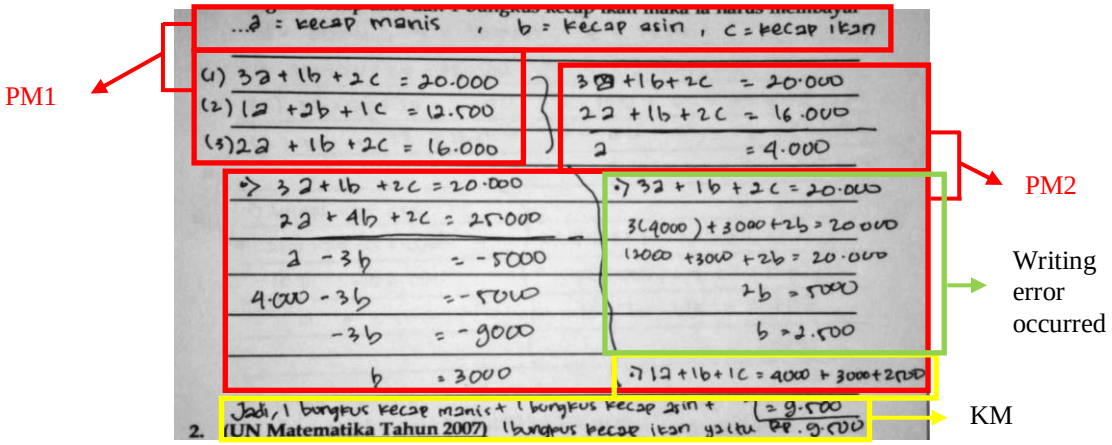

Figure 4. Answer SS in number 1

Based on Figure 4, it can be identified that SS understands the problem by writing things that are known but SS does not write what is asked in PM1. SS also does not write clearly, equation 1, 2, and 3 belongs to whom. SS also wrote a coherent solution but it was unclear because SS did not provide any information regarding the plot or method used in PM2. SS also made a writing error on PM2. Furthermore, SS wrote a conclusion using a mathematical sentence and translated it using his own sentence. SS did a double check but SS did not write it so the SS answer was correct but it did not fill the mathematical communication indicator that is evaluation. This was also shown in the interview between researcher and SS.

R : Do you understand the purpose of this story problem?
SS: Yes, I do. In this problem 1, there are 3 people known where each person bought 3 items. Asked the price of each item and then asked to find out how much money Tamara has to pay.
R : Why didn't you write what it asked?
SS: I wrote but in the end while answering it.
R : I don't think that's what was asked but it's your answer. So you don't write down what is asked.

→ Understanding PM1

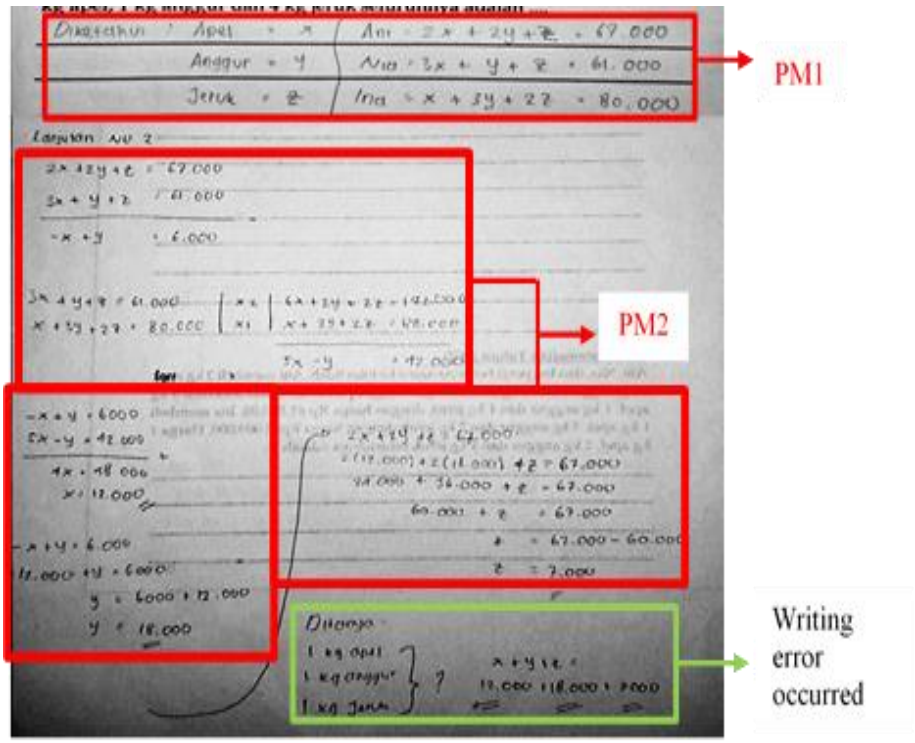

Figure 6. Answer SR in number 1

Based on Figure 6, it can be identified that SR understands the problem by writing things that are known but SR does not write what is requested on PM1. SR writes what is known by elaborating one by one to make the system of the equation clearer. SR also wrote a coherent solution but it was unclear because SR did not provide any information regarding the plot or method used in PM2. Furthermore, SR writes conclusions using mathematical sentences but SR does not explain clearly using their sentences. SR does not do double checks. Therefore, SR's answer was wrong and SR did not answer perfectly. This was also shown in the interview between researcher and SR. See the transcript of the interview in Figure 7.

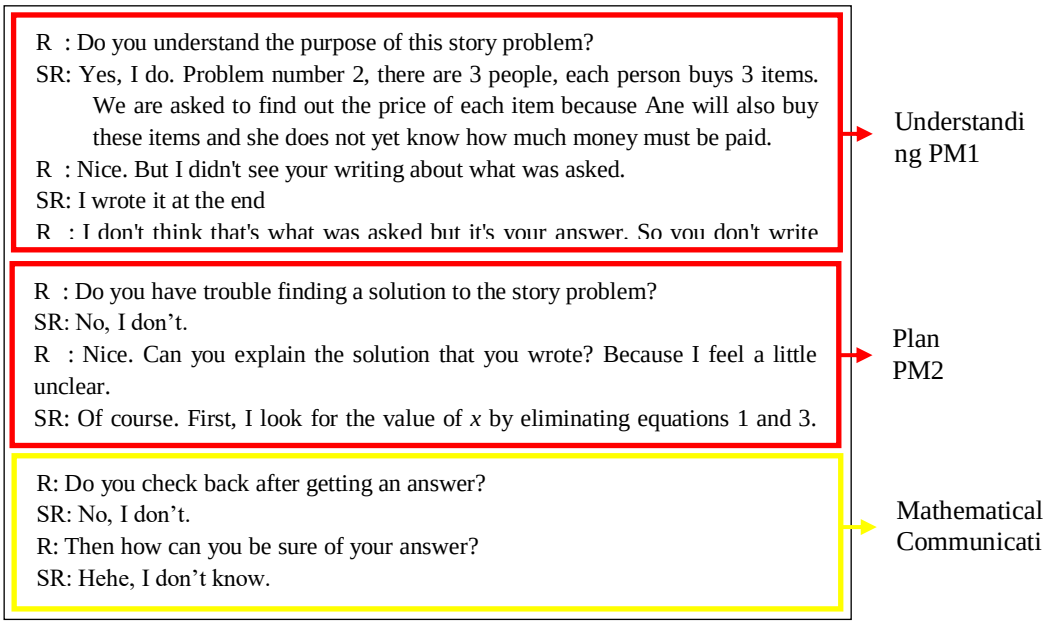

Figure 7. Interview about Understanding, Plan, and Mathematical Communication of SR

Conclusion

From the results of student work, the value of each student can be written to determine the categories of student communication skills and problem-solving abilities is based on the score guidelines that have been mentioned before shown in Table 6.

Table 6. Score of Student Work

Question Item	Aspects		Score		
			SH	SM	SL
1	Problem-Solving Abilities	Understanding	4	4	4
		Plan	4	3	3
		Look Back	2	2	0
	Mathematics Communication Skills	Writing	3	1	2
		Oral	4	3	2
2	Problem-Solving Abilities	Understanding	4	4	4
		Plan	4	3	3
		Look Back	2	2	0
	Mathematics Communication Skills	Writing	3	2	1
		Oral	4	3	2
3	Problem-Solving Abilities	Understanding	4	4	4
		Plan	4	3	3
		Look Back	2	2	0

Mathematics Communication Skills	Writing	3	2	2
	Oral	4	3	2
Total Score (Problem-Solving Abilities)		30	27	21
Total Score (Mathematics Communication)	Writing	9	5	5
	Oral	12	9	6

Data in Table 6 shows the differences in scores on problem-solving abilities and mathematical communication skills. Students with high-level mathematical abilities have high-level problem-solving abilities because ST can understand each given problem, can solve problems, and also check again. However, for the level of mathematical communication skills in writing, ST is included in the medium category. That is because ST can write coherently and clearly, ST does not write the results of re-checking, and ST also only provides conclusions using mathematical sentences but does not provide conclusions with their own sentences. As for the level of oral mathematical communication skills, ST is included in the very high category. That's because ST can communicate coherently and clearly, ST does a double-check so that the answer is correct, and ST gives conclusions using mathematical sentences and with their own sentences.

Students with medium-level mathematical abilities have medium problem-solving abilities because SS can understand each given problem, can solve problems but is less coherent and clear, and also re-check. However, for the level of mathematical communication skills in writing, SS is included in the very low category. That is because SS can write problems clearly but not coherently, SS does not write the results of re-checking then there are some writing errors, and SS gives conclusions using mathematical sentences and with their own sentences. As for the level of oral mathematical communication skills, SS is included in the medium category. That's because SS can communicate coherently and a little less clearly, SS does a double-check so that the answer is correct, and SS provides conclusions using mathematical sentences and with their own sentences.

Students with low-level mathematical abilities have a low-level problem- solving skills because SR can understand each given problem, can solve the problem but there are problems that are solved incomplete, and also do not check again so that there are answers given incorrectly. However, for the level of mathematical communication skills in writing, SR is included in the very low category. That is because SR can write problems clearly but not coherently, SR does not write the results of re-checking so there are wrong answers, and SR also only gives conclusions using mathematical sentences but does not provide conclusions with their own sentences. As for the level of oral mathematical communication skills, SR is included in the low category. That is because SR can communicate clearly but not coherently, SR does not re-check so there are wrong answers, and SR gives conclusions using mathematical sentences and with their own sentences.

These results indicate that communication skills are in line with the ability to solve problems and are influenced by the level of mathematical ability. This is different from Nurhasanah (2019) which states that students make a lot of mistakes in workmanship so that students' communication skills are considered low. Whereas in this research, the level of mathematical abilities influences the mistakes made by students.

Conclusion

Based on the results and discussion, it can deduce students' mathematical communication skills in line with their ability to solve problems for story problems. This is influenced by the level of mathematical abilities of each student. The higher the mathematical abilities of each student, the higher the mathematical communication skills and problem-solving abilities. However, this influence will differ in mathematical communication skills both written and oral. Students tend to be better at solving story

problems by communicating orally rather than in writing. This can be seen in the scores obtained by students, oral communication skills scores higher than the skills to write.Therefore, for further research, it is suggested that other researchers can develop the design of learning methods or instructional media that can improve students' mathematical communication skills in writing. It will be useful for teachers to know the profile of students' mathematical communication skills and use them to evaluate learning methods.

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