Students' problem-solving ability: An analytical practice viewed from the aspect of sociomathematical norm

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ABSTRACT

This research aims to analyze students' problem-solving ability in terms of sociomathematical norms. Data was collected using questionnaire sociomathematical norms, ability description tests, and interviews. The total subjects in the research were six students consisting of two students with high sociomathematical norms, two students with moderate sociomathematical norms, and two students with low sociomathematical norms. In this research, there are four indicators, namely understanding the problem, planning the problem, solving the problem, and re-examining the answer. The results showed that subjects who had high sociomathematical norms were able to solve questions on all indicators. Subjects with moderate sociomathematical norms are able to solve problems on the indicators of understanding, planning, and solving problems, but there are errors in the indicators of re-examining. Subjects who have low sociomathematical norms are able to solve problems on the indicators of understanding and planning problems but there are errors in the indicators of solving problems and re-examining.

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INTRODUCTION

Learning improvement must continue to be carried out comprehensively toward optimal learning to develop students' thinking skills (Maarif et al., 2020). One way to develop students' thinking skills is through the process of learning mathematics, because in solving mathematical problems students need to think so that students must have the ability to solve problems (Rahmazatullaili et al., 2017). Problem-solving ability is a complex thinking activity, as a process in solving a problem encountered, which requires several ways to solve it (Maarif et al., 2018; Purwaningsih & Ardani, 2020). According to Abdiyani et al. (2019), problem-solving is a cognitive activity of students, using all the knowledge and experience they have. Solving skills are very important for students to be able to solve various forms of mathematical problems. Problem-solving encourages students to solve mathematical problems and provides broad opportunities to think and think

systematically when getting a problem using previous knowledge (Yustiana et al., 2021). The research of Riyadi et al. (2021) explained that one of the focuses of educational goals, namely the development of problem-solving skills. The problem-solving ability of students is still low, it can be seen from the way they write their answers and do not do other stages (Widodo et al., 2018). In addition, the research results of Akbar et al. (2017) and Utami & Wutsqa (2017) show that the problem-solving abilities of junior high and high school students are low because they are below 50% based on the average results of the achievement of each indicator in solving problems. From these facts and research, it can be concluded that the ability of students to solve mathematical problems is still low. Therefore, students are still considered unable to solve problems.

Each student must have different difficulties in solving a mathematical problem (Chabibah et al., 2019). These problems can be in the form of student factors in the steps to solve the problems being faced (Noto et al., 2017). The success of students in solving problems is certainly influenced by several factors, one of which is sociomathematical norms. In line with the opinion of Ningsih & Maarif (2021) who stated that problem-solving is related to sociomathematical norms because these sociomathematical norms focus on how problem-solving should be done. The importance of sociomathematical norms is stated in Zembat & Yasa (2015), sociomathematical norms are an important part of educator knowledge in terms of supporting the mathematical development of students and shaping the quality of social interaction in the classroom.

Sociomathematical norms were first introduced by Yackel et al. (2000), they extended their research from general class norms to the normative aspects of mathematical arguments about student activity, distinguishing between social and sociomathematical norms. Where social norms refer to regularities in interaction patterns that govern social interactions in the classroom, while sociomathematical norms are specific to mathematics. Normative aspects specifically related to mathematics, such as an implicit understanding of what constitutes an acceptable mathematical explanation and the technological means that can support mathematical explanation, are referred to as sociomathematical norms (Wahyu et al., 2021; Yackel et al., 2000).
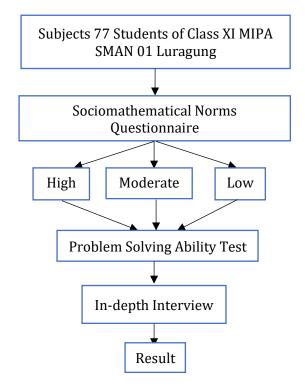
Several studies are relevant to this research regarding problem-solving abilities, namely, the research conducted by Chabibah et al. (2019) which examined mathematical problem-solving and adversity quotient. The results of their research explain that the ability of students to solve story problems varies based on the level of adversity quotient. Then the research conducted by Purwaningsih & Ardani (2020) examined problem-solving based on learning styles and gender. The results showed that there were differences in mathematical problem-solving abilities between male and female students. The problem-solving ability of each student is different based on the level of learning motivation. The drawback of these relevant studies is that none of them have discussed problem-solving abilities and sociomathematical norms.

Research on sociomathematical norms has been carried out, including research by Ningsih & Maarif (2021) sociomathematical norms in learning mathematics. The results of their research showed that each level of sociomathematical norms will affect the results obtained by students in learning mathematics. Then the research of Anisa et al. (2019) examined sociomathematical norms and students' interest in learning mathematics. The results of their research explain that sociomathematical norms can

be said to be good if interest in learning mathematics is also good. The weakness in the studies above is that no one has discussed sociomathematical norms on problem-solving abilities.

Based on the description above, the mathematical problem-solving ability of students in Indonesia is still low and sociomathematical norms have an effect on problem-solving and no one has researched specifically on mathematical problem-solving of students in terms of sociomathematical norms, so the purpose of this research is to analyze students' mathematical problem-solving abilities in terms of sociomathematical norms.

METHOD

This research uses descriptive qualitative research methods. Qualitative descriptive research is a type of research conducted to find out facts, phenomena, or symptoms more accurately to determine the characteristics of a population in a particular area (Hardani et al., 2020). The flow chart of the used method can be seen in Figure 1.
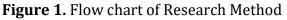

Figure 1. Flow chart of Research Method

Figure 1 shows a flow chart of the research method used. The subjects in this research were students of class XI MIPA SMAN 01 Luragung, totaling 78 students who were then selected into 6 students based on the level of sociomathematical norms in the high, medium, and low categories.

Data were collected through questionnaires, ability description tests, and interviews. The questionnaire in this research was used to measure the sociomathematical norms of students and this questionnaire is an adaptation of Anisa et al. (2019). The test instrument given aims to measure students' problem-solving abilities. The material on the test instrument is about a three-variable linear equation system (SPLTV). Interviews were conducted to see if there were differences in the students in providing oral and written information. The interview material is about the results of the answers to the description tests that have been done. Before being given to research subjects the instruments went through the validation stage by the validator and were declared valid, then performed a reliability test using IBM SPSS Statistics using Cronbach's alpha and the results showed that the data was reliable, so the instrument could be used and given to research subjects.

The research subjects are from class XI students of SMAN 01 Luragung, Kuningan. The total subjects in this research were 6 students consisting of 2 students with high sociomathematical norms, 2 students with moderate sociomathematical norms, and 2 students with low sociomathematical norms. The sampling technique in this research used purposive sampling. This data collection begins with filling out a questionnaire, followed by doing a test of problem-solving ability descriptions, and finally an interview (Maarif et al., 2019). Triangulation is a method to check the validity of this research data. Indicators of

problem-solving ability used in this study are indicators based on Polya, namely understanding the problem, planning the problem, solving the problem, and re-examining. Questionnaires given to students refer to aspects of sociomathematical norms such as mathematical experience, mathematical explanations, mathematical differences, mathematical communication, mathematical effectiveness, and mathematical insight (Ningsih & Maarif, 2021).

RESULTS AND DISCUSSION

Based on the results of the analysis of the sociomathematical norms questionnaire, each student has sociomathematical norms with different levels. There are 57 students who have high sociomathematical norms, 15 students who are in the medium category, and 6 students who have low sociomathematical norms. This categorization uses the standard deviation. The formulas and the results of the questionnaire analysis at each level of sociomathematical norms can be seen in Table 1.

Table 1. Distribution of Sociomathematical Norms based on Level

Category	Formula	Criteria	Frequency
Low	X<M-SD	X<25.33	6
Moderate	M-SD<=X<M+SD	25.33≤X<36.67	15
High	M+SD<=X	36.67≤X	57

Research subjects who have been categorized at each level of sociomathematical norms, then work on as many as 4 item questions with the material of a three-variable linear equation system (SPLTV). After that, analyze their answers to determine the informants. The purposive sampling technique was used to select informants. The six informants who became subjects in this research are presented in Table 2.

Table 2. Informant Data

Student Code	Category
T1	High
T2	High
S1	Moderate
S2	Moderate
R1	Low
R2	Low

After determining the subject of the informant, then analyzing the results of their answer tests on the SPLTV material in terms of sociomathematical norms. The results of the tests carried out by T1 are presented in Figure 2.

Figure 2. T1 Answer Results

Figure 2 shows that T1 is able to work on questions and fulfills all indicators ranging from understanding the problem, planning the problem, completing the plan to re-checking the answer. The following are the results of an interview with T1.

Researcher	:	Do you understand the question no. 1?
Subject	:	Yes, I understand.
Researcher	:	If you understand it, please try to rephrase question no. 1 in your own words?
Subject	:	Ibrahim bought 4 rulers, 6 books, and 2 pens for 19,000; Sulaiman bought 1 ruler, and 3 books at a price of 7,000; Rido bought 2 rulers, 4 books, and 1 pen

for 11,500, what is asked is the price of 1 pen.

Researcher : Then what method did you use to solve the problem and how?

Subject : Using SPLTV, first convert it to equation form then eliminate the equation, then substitute and the answer is obtained.

Researcher : Are you sure your answer is correct?

Subject : Yes, because I have been thorough and have checked again.

Based on the results of the interview in question number 1, T1 was able to determine the elements that were known or asked as a whole correctly, stated the problem in mathematical symbols, was able to explain how to solve the problem, and re-examined the answer.

Based on the written test data and analysis of the interview results, then to find out whether the data is valid or not, the researchers made a comparison. T1 is able to re-explain the questions and write down the elements in the questions correctly. T1 is also able to go through the stage of formulating a problem because T1 is able to state the problem in mathematical symbols and is able to determine the method used to solve the problem. T1 is able to solve the problem according to the settlement strategy in the previous stage. In addition, T1 is also able to go through the stage of re-examining the answers, because T1 provides answers and conclusions correctly.

The results of the answers from informants T2 are presented in Figure 3.

Figure 3. T2 Answer Results

Figure 3 shows that T2 is able to work on the questions and fulfills all indicators starting from understanding, planning, and completing planning and re-checking answers. The following are the results of an interview with T2.

Researcher : Do you understand the question no. 1?

Subject : Yes, I understand.

Researcher : If you understand it, please try to rephrase question no. 1 in your own words?

Subject : So, the equation is Ibrahim $4x+6y+2z = 19,000$; Sulaiman $x+3y = 7,000$; Rido $2x+4y+z = 11,500$, which is asking for the price of z.

Researcher : Then what method did you use to solve the problem and how?

Subject : I use logic, so the items that Ibrahim, Sulaiman and Rido bought were calculated first, then divided by the money they paid.

Researcher : Are you sure your answer is correct?

Subject : Yes, because I have checked and the results are the same.

Based on the results of the interview in problem number 1, T2 is able to determine the elements that are known or asked as a whole correctly, state the problem in mathematical symbols, was able to explain how to solve problems with other methods, and re-examine the answers correctly.

Based on the written test data and analysis of the interview results, so to find

out whether the data is valid or not, the researchers made a comparison. T2 is able to re-explain the problem and write down the elements in the problem correctly. T2 is also able to go through the stage of formulating a problem because T2 is able to state the problem in mathematical symbols and is able to solve the problem in another way that is more effective. T2 is able to solve the problem according to the strategy or settlement plan at the previous stage. In addition, T2 is also able to go through the stage of re-examining the answers, because T2 provides answers and conclusions correctly even though using a logical solution.

The results of the problem-solving test answers from S1 informants are presented in Figure 4.

Figure 4. S1 Answer Results

Figure 4 shows that S1 is able to work on problems and fulfill the indicators of understanding problems, planning problems, and completing plans. However, S1 has not been able to go through the stage of re-checking the answers. The following are the results of an interview with S1.

Researcher : Do you understand the question no. 1?
Subject : Yes, I understand.
Researcher : If you understand it, please try to rephrase question no. 1 in your own words?
Subject : Ibrahim 4x+6y+2z = 19.000; Sulaiman x+3y = 7.000 and Rido 2x+4y+z =

11.500, what is asked is the price of 1z.
Researcher : Then what method did you use to solve the problem and how?
Subject : Eliminate equations 1 and 3 and obtained y, then substitute into equation 2, obtained z, and finally substitute y and x in equation 1 so that z is obtained.
Researcher : Are you sure that your answer is correct?
Subject : Not sure, because it hasn't been checked

Based on the results of the interview in problem number 1, S1 was able to determine the elements that were known or asked as a whole correctly, stated the problem in mathematical symbols, and was able to explain how to solve the problem. But S1 has not been able to go through the stage of re-checking the answer.

Based on the written test data and analysis of the interview results, so to find out whether the data is valid or not, the researchers made a comparison. S1 is able to re-explain the questions and write down the elements in the questions correctly. S1 is also able to go through the stage of formulating problems because S1 is able to express problems into mathematical symbols and is able to determine what method is used to solve the problem. In addition, S1 is able to solve problems according to the strategy or settlement plan at the previous stage. However, S1 has not been able to go through the stage of re-checking the answers, even though S1 gives the correct answer but S1 does not provide conclusions when working and does not re-check the answers during the interview, so S1 is said to have not been able to go through the stage of re-examining the answers.

The results of the answers from informants T2 are presented in Figure 5.

Figure 5. S2 Answer Results

Figure 5 shows that S2 is able to work on problems and fulfill the indicators of understanding problems, planning problems, and completing plans. However, in completing the implementation it was not quite right and S2 had not been able to go through the stage of re-examining the answers. The following are the results of an interview with S2.

Researcher : Do you understand the question no. 1?

Subject : Yes, I understand.

Researcher : If you understand it, please try to rephrase question no. 1 in your own words?

Subject : Suppose it becomes $4x+6y+2z = 19,000$; $x+3y = 7,000$ and $2x+4y+z = 11,500$, asked for the price of $1z$.

Researcher : Then what method did you use to solve the problem and how?

Subject : Use elimination, but it seems wrong because I do not get the answer yet.

Based on the results of the interview, S2 is able to determine what is known and asked about problem number 1 as a whole correctly and stated the problem in mathematical symbols. However, S2 has not been able to go through the stage of solving the problem and re-checking the answers, because S2 has not solved the given problem.

Based on the written test data and analysis of the interview results, so to find out whether the data is valid or not, the researchers made a comparison. S2 is able to re-explain the questions and write down the elements in the questions correctly. S2 is also able to go through the stage of formulating problems because S2 is able to express problems into mathematical symbols correctly. S2 is able to solve the problem, but it is not in accordance with the strategy or settlement plan at the previous stage. S2 also has not been able to go through the stage of re-examining the answers, because S2 has not solved the problems given.

The results of the problem-solving test answers from informant R1 are presented in Figure 6.

Figure 6. R1 Answer Results

Figure 6 shows that R1 is able to work on questions and fulfill the indicators of understanding problems and planning problems and completing plans. However, in completing the implementation it was not quite right and R1 had not been able to go through the stage of re-examining the answers. The following are the results of an interview with R1.

Researcher : Do you understand the question no. 1?

Subject : Yes, I understand.

Researcher : If you understand it, please try to rephrase question no. 1 in your own words?

Subject : It is known that Ibrahim is 4x+6y+2z = 19,000; Sulaiman is x+6y = 7,000; Rido is 2x+4y+z = 11,500; asked z.

Researcher : Then what method did you use to solve the problem and how?

Subject : Use the elimination method, then the results is obtained.

Researcher : Are you sure your answer is correct?

Subject : Yes, I am sure, but I haven't re-check it.

Based on the results of the interview, R1 was able to determine what was known or asked about problem number 1 as a whole correctly and stated the problem in mathematical symbols. However, R1 has not been able to go through the stage of solving the problem and re-checking the answers, because R1 solves the problem that is not quite right so that the resulting answer is wrong.

Based on the written test data and analysis of the interview results, so to find out whether the data is valid or not, the researchers made a comparison. R1 is able to re-explain the problem and write down the elements in the question correctly. R1 is also able to go through the stage of formulating a problem because R1 is able to express the problem into mathematical symbols correctly. R1 is able to solve the problem, but it is not in accordance with the strategy or settlement plan at the previous stage. R1 has also not been able to go through the stage of re-examining the answers, because in solving the problem it is not quite right so the resulting answer is not appropriate.

The results of the answers from informants T2 are presented in Figure 7.

Figure 7. R2 Answer Results

Figure 7 shows that R2 is able to work on the questions and fulfill the indicators of understanding the problem, and planning the problem. However, R2 has not been able to solve the problem and has not been able to go through the stage of re-examining the answers. The following are the results of an interview with R2.

Researcher : Do you understand the question no. 1?

Subject : Yes, I understand.

Researcher : If you understand it, please try to rephrase question no. 1 in your own words?

Subject : The equation is Ibrahim 4x+6y+2z = 19,000; Sulaiman x+6y = 7,000; Rido 2x+4y+z = 11,500; asked to find z.

Researcher : Then what method did you use to solve the problem and how?

Subject : Use the elimination method, but I forgot how to do it so it is not finished yet.

Based on the results of the interview, R2 was able to determine what was known or asked about problem number 1 as a whole correctly and stated the problem in mathematical symbols. However, R2 has not been able to go through the stage of solving the problem and rechecking the answers, because R2 has not solved the problem given.

Based on the written test data and analysis of the interview results, so to find

out whether the data is valid or not, the researchers made a comparison. R2 is able to re-explain the problem and write down the elements in the problem correctly. R2 is also able to go through the stage of formulating a problem because R2 is able to express the problem into mathematical symbols correctly. R2 was able to solve the problem, but it was not in accordance with the strategy or settlement plan at the previous stage. R2 also has not been able to go through the stage of re-examining the answers, because R2 has not solved the problems given.

Based on data analysis regarding problem-solving conducted by students in terms of sociomathematical norms, it can be concluded that students with high sociomathematical norms have a high willingness to learn, can find solutions to problems, are able to accept differences of opinion, tends to be active in class, always trying to use the fastest or easiest way so that the answers become more practical, and interested in finding other reading sources to increase their knowledge. This will have an impact on learning where students with high sociomathematical norms will be easier and more active in solving problems and facilitating further research if they want to explore high-level sociomathematical norms on other topics.

Students with moderate sociomathematical norms can carry out mathematics learning well, are able to solve the problems given, accept differences of opinion in discussions, are less able to interact with other students in discussing problems, sometimes find more effective and easy solutions, and are less interested in finding solutions from other reading sources. This will have an impact on learning where students with moderate sociomathematical norms will find it easy to solve problems and facilitate further research if they want to explore moderate sociomathematical norms on other topics.

Students with low sociomathematical norms have not been able to carry out or pay attention to mathematics learning in class well, have not been able to solve problems well, tend to be passive in class, are able to accept differences, have not been able to find effective and easy solutions and are not interested in finding other reading sources to increase their knowledge. This will have an impact on learning where students with low sociomathematical norms will find it difficult and tend to be passive in solving problems and facilitate further research if they want to explore low-level sociomathematical norms on other topics.

The description of the results regarding problem-solving abilities with high sociomathematical norms, namely students with high sociomathematical norms are able to work on questions systematically and fulfill 4 problem-solving indicators starting from understanding the problem, T1 and T2 are able to identify what is known or asked about the problems that have been given. Planning the problem, at this stage T1 and T2 are able to convert the problem into mathematical form and are able to write down ways to solve it. In solving problems, T1 and T2 are also able to solve problems according to the plan or strategy at the previous stage and even able to solve in other ways, namely using logic correctly and precisely. Re-examine, T1 and T2 were able to answer the problem correctly and draw conclusions from the results obtained correctly. It can be concluded that the subjects with higher sociomathematical norms are, the higher the problem-solving ability. In line with the research results of Aslamiah (2018) which explained that sociomathematical norms are positively correlated with mathematics learning outcomes or students who have high sociomathematical norms, their mathematics learning achievement is also high.

Students with moderate sociomathematical norms who are currently able to work on 3 of 4 indicators, namely, understanding the problem, S1 and S2 are able to know the elements that are known or asked about the problems that have been given. Planning the problem, at this stage S1 and S2 are able to convert the problem into a mathematical model and are able to write down ways to solve it. Solving problems, overall S1 and S2 are also able to solve problems according to the plan or strategy at the previous stage. Re-examine, seen from the overall analysis of the S1 and S2 answers, there are still errors in answering the problems, and do not make conclusions from the results obtained. It can be concluded that subjects with moderate sociomathematical norms have moderate problem-solving abilities because they are able to work on three of the four indicators of solving ability. This is in line with the research results of Lutfianannisak & Sholihah (2018) that moderately capable students are able to represent problems in mathematical form and work on problems systematically. The research results of Ningsih & Maarif (2021) and Wahyu et al. (2021) show that the current sociomathematical norms will affect the average results obtained by students in learning.

Students with low sociomathematical norms are able to fulfill 2 of 4 indicators, namely, understanding the problem, R1 and R2 are able to identify elements that are known or asked about the problems that have been given. Planning the problem, at this stage R1 and R2 are able to convert the problem into a mathematical model and are able to write down ways to solve it. Solving problems, R1 and R2 have not been able to solve the problem according to the plan or strategy at the previous stage and there are errors in solving the problem. Re-examine, seen from the overall analysis of the answers, R1 and R2 have not been able to go through the re-examination stage, because they have not been able to solve the problems given so they have not found the answers to these problems. It can be concluded that subjects with low sociomathematical norms have low problem-solving abilities because they are only able to work on 2 out of 4 indicators. This is in line with research of Nugraha & Basuki (2021) which explained that students with low problem-solving abilities have not been able to complete the steps for solving problems and are not accustomed to re-examining answers carefully. The research results of Ningsih & Maarif (2021) show that low sociomathematical norms will affect the low results obtained by students in learning.

CONCLUSIONS AND SUGGESTIONS

Based on the results and analysis, it can be concluded that students with high sociomathematical norms are able to solve problems and work on the four problem-solving indicators, namely understanding, planning, solving problems, and re-examining answers. Students with moderate sociomathematical norms are able to work on questions and fulfill 3 of 4 indicators, namely understanding, planning, and solving problems, while students with low sociomathematical norms have not been able to work on questions and meet 2 of 4 indicators, namely the indicator of understanding and planning problems. Therefore, the results show that students with high sociomathematical norms will also have high results obtained in learning mathematics, as well as students with moderate or low sociomathematical norms, will also affect medium and low results obtained in learning mathematics.

This research is still limited to the SPLTV topic and in class XI SMAN 1 Luragung. Therefore, the researchers suggest further research to explore further related sociomathematical norms

or students' problem-solving abilities in other topics and levels of education and can use this research as a reference to develop sociomathematical norms in learning mathematics.

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