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Analysis Study of Mathematical Representation Skills of High School Students Seen from the Perspective of *Sociomathematical Norms*

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Abstract

The purpose of this study was to evaluate students' mathematical representation skills in light of sociomathematical norms. With a descriptive strategy, this study employs a qualitative methodology. 115 students from Jakarta's class XI MIPA SMA Negeri 105 served as the study's subjects. To study the extent of students' ownership of sociomathematical norms, the study first administered a questionnaire. Once the level of sociomathematical norms that students possessed was known, the research was carried out using purposive sampling based on the level of norms in the low, medium, and high categories. Purposive sampling in this study was conducted by selecting 2 students at each level of sociomathematical norms to perform a mathematical representation ability test. Sociomathematical norms research including 115 students revealed that 5 students have low sociomathematical norms, 75 students have moderate sociomathematical norms, and 35 students have high sociomathematical norms. While the findings of the analysis of the representation ability exam indicate that students with high sociomathematical norms are capable of meeting all indicators of mathematical representation ability, this is not the case for students with low sociomathematical norms, Students with moderate sociomathematical norms can meet two markers of mathematical representation competence, but students with poor sociomathematical norms can meet only one indicator.

Keywords: *Representation, Sociomathematical Norms*

Introduction

Learning mathematics has multiple objectives, including the development of reasoning, connection, and problem-solving skills, all of which involve communication in the form of mathematical representations (Nurfitriyanti et al., 2020). Then, according to research conducted by Syafri (2017), learning mathematics refers to students' mathematical abilities, which include representation, connection, problem solving, communication, evidence, and reasoning (Hartono et al., 2019)

According to the research of Santia et al. (2019), mathematical representation ability is the capacity of pupils to produce and communicate their mathematical ideas. Numerous mathematical concepts include numerical systems, the creation of mathematical equations, algebraic form statements, graphs, geometric drawings, and number lines (Hernawati, 2016). The fact that mathematical representation ability describes a foundation for students' mathematical comprehension in mathematics demonstrates the significance of students' mathematical representation abilities (Sulastri et al., 2017). This is supported by Sapitri and Ramlah's (2019) assertion that the capacity for mathematical representation is a prerequisite for comprehending and solving mathematical problems.

According to the research of Yudhanegara and Lestari (2015), Indonesian students' ability to portray information is still categorized as low. Then, the findings of Herdiman et al. (2018) demonstrate that the pupils' capacity to describe mathematical expressions in words, visually, and symbolically is relatively limited. Then, according to a study conducted by Sari et al. (2020), the representation capacity of high school pupils in the Singkawang region was poor. From this, it may be deduced that the students' capacity for mathematical representation is still somewhat limited.

Mathematical representation ability is essential for learning mathematics since the learning objectives include problem solving and mathematical communication, where both representation skills are required to develop mathematical models and comprehend issue solutions (Yenni & Sukmawati, 2020). With representation skills, it is possible for pupils to comprehend mathematical concepts and relate them from one notion to a variety of other concepts represented in various formats (Fitrianingrum & Basir, 2020). Numerous factors influence mathematics learning, one of which is sociomathematical norms, which play a significant role in improving the quality of mathematics learning since they relate to the social interactions of students during the learning process (Dini & Maarif, 2022). According to Arwadi et al. (2022), *sociomathematical norms* play a role in improving student learning outcomes and shaping student personalities in mathematics learning. Then, according to Sulfikawati et al. (2016), *sociomathematical norms* are a social interaction with the purpose of fostering mathematical comprehension and enhancing mathematical knowledge.

Yackel and Cobb (1996) explored the dissimilarity between social norms and *sociomathematical norms* in their research, which marked the beginning of the development of *sociomathematical norms*. Social norms pertain to the conventions of students' social interactions throughout learning in general. The *socio-mathematical norms* are social norms that are more concentrated on studying mathematics, such as discussions about solving mathematical problems, comprehension of mathematical concepts, etc (Yackel et al., 2000). Therefore, sociomathematics signifies the relationship between humans, groups, and mathematics (Kadir, 2008). Therefore, the definition of *sociomathematical norms* relates to the behavior that students and teachers should exhibit when learning mathematics (Rizkianto, 2013). Then, according to Utari (2017), *sociomathematical norms* pertain to how students position themselves in social connections in order to develop mathematical comprehension and solve mathematical issues.

Several prior investigations on the capability of mathematical representation are comparable to the current investigation. In a study by Komala and Afrida (2020), vocational school students' representational abilities were examined in terms of their learning styles. His research demonstrates that pupils with kinesthetic learning styles have superior representational skills compared to those with other learning styles. Other research includes that of Umaroh and Pujiastuti (2020) regarding gender disparities in PISA issues and representational ability. The findings of his study explicate the distinctions between men and women in terms of visual and symbolic representation.

There has been research on *sociomathematical norms*, such as the study by Rofiq et al. (2017) that examined *sociomathematical norms* in collaborative learning. The findings of his study show that students with various sociomathematical levels participate in collaborative learning. Widodo et al (2019)'s study on the evolution of *sociomathematical norms* via educational media is yet another example. According to the findings of his study, pupils can employ visual learning materials to correlate with one another, which can lead to a rise in *sociomathematical norms*.

There hasn't been any research on mathematical representation abilities seen from the perspective of *sociomathematical norms*, so the study was conducted with the aim of analyzing students' mathematical representation abilities in terms of *sociomathematical norms* based on the explanation that has been described showing the lack of mathematical representation abilities of Indonesian students and aspects of *sociomathematical norms* that affect mathematics learning.

Method

This study used a qualitative descriptive methodology, which is research that begins with observations of individuals and produces written or spoken descriptions of the findings (Yulinawati & Nuraeni, 2021). Six students were chosen from a group of 115 class XI MIPA SMAN 105 Jakarta pupils based on their *sociomathematical norms* scores in the high, medium, and low categories.

An interview, test, and questionnaire were employed in this investigation. The questionnaire tool was used to assess the extent of students' adherence to sociomathematical standards. Anisa et alquestionnaire's was modified for use in this study (2019). The test is meant to gauge how well students can represent mathematical concepts in linear programming coursework. To learn more in-depth information or to learn about things not covered by the test instrument, interviews were undertaken. The validator assessed the student testing instrument's validity and reliability using IBM SPSS Statistics, and the instrument was deemed valid with a significance value of each item of < 0.05 or less. The findings of the validity test of the *sociomathematical norms* questionnaire are shown in table 1 below, and those of the validity test of the mathematical representation ability instrument test are shown in table 2.

Table 1. Results of the Validity Tests for Sociomathematical Norms

		Total
x1	Pearson Correlation	.677**
	Sig. (2-tailed)	0,000
	N	40
x2	Pearson Correlation	.375*
	Sig. (2-tailed)	0,017
	N	40
x3	Pearson Correlation	.419**
	Sig. (2-tailed)	0,007
	N	40
x4	Pearson Correlation	.723**
	Sig. (2-tailed)	0,000
	N	40
x5	Pearson Correlation	.693**
	Sig. (2-tailed)	0,000
	N	40
x6	Pearson Correlation	.424**
	Sig. (2-tailed)	0,006
	N	40
x7	Pearson Correlation	.506**
	Sig. (2-tailed)	0,001
	N	40
x8	Pearson Correlation	.638**
	Sig. (2-tailed)	0,000
	N	40
x9	Pearson Correlation	.445**
	Sig. (2-tailed)	0,004
	N	40
x10	Pearson Correlation	.431**
	Sig. (2-tailed)	0,005
	N	40
x11	Pearson Correlation	.441**
	Sig. (2-tailed)	0,004
	N	40
x12	Pearson Correlation	0,312
	Sig. (2-tailed)	0,050
	N	40
x13	Pearson Correlation	.558**
	Sig. (2-tailed)	0,000
	N	40
x14	Pearson Correlation	.442**
	Sig. (2-tailed)	0,004
	N	40
x15	Pearson Correlation	.703**
	Sig. (2-tailed)	0,000
	N	40
x16	Pearson Correlation	.654**
	Sig. (2-tailed)	0,000
	N	40
x17	Pearson Correlation	.554**
	Sig. (2-tailed)	0,000
	N	40

x18	Pearson Correlation	.645**
	Sig. (2-tailed)	0,000
	N	40
x19	Pearson Correlation	.561**
	Sig. (2-tailed)	0,000
	N	40
x20	Pearson Correlation	.602**
	Sig. (2-tailed)	0,000
	N	40
x21	Pearson Correlation	.600**
	Sig. (2-tailed)	0,000
	N	40
x22	Pearson Correlation	.418**
	Sig. (2-tailed)	0,007
	N	40

Table 2. Report on Validity of Instruments Used in Mathematical Representation

		Total
x1	Pearson Correlation	.652**
	Sig. (2-tailed)	0,000
	N	40
x2	Pearson Correlation	.332*
	Sig. (2-tailed)	0,036
	N	40
x3	Pearson Correlation	.518**
	Sig. (2-tailed)	0,001
	N	40
x4	Pearson Correlation	.829**
	Sig. (2-tailed)	0,000
	N	40
x5	Pearson Correlation	.771**
	Sig. (2-tailed)	0,000
	N	40

Purposive sampling was used in this study's sampling process. After completing a questionnaire, 6 students were chosen to participate in a descriptive test of mathematical representation ability. Of these, 2 students had *sociomathematical norms* that were below average, 2 had norms that were moderately below average, and 2 had norms that were below average. high *sociomathematical norms*, following which interviews were held (Maarif et al., 2019). The Graciella and Suwangsih (2016) study's representation ability indicators were altered for use in this study, and they are as follows:

a. Visual representation:
   1) enables the creation of a mathematical problem's visual representation.
   2) creating an image from a mathematical model
b. Symbolic Representation:
   1) In order to solve mathematical issues, develop a symbolic mathematical model.
   2) Converting images into mathematical models in math problems

Verbal Representation: Use language to express solutions to mathematical difficulties.

Results and Discussion

Each student has a varied level of *sociomathematical norms*, according to the findings of the sociomathematical norms questionnaire study completed by 115 students. In comparison to the 75 students who have moderate *sociomathematical norms* and the 35 students who have high sociomathematical norms, there are 5 students who have low *sociomathematical norms*. Using the standard deviation, one may gauge the extent of the *sociomathematical norms* category that students possess. Table 3 displays the findings of the research and the formulas for each level of *sociomathematical norms*.

Tabel 3. Distribution of Sociomathematical Norms by Category

Category	Formula	Criteria	Frequency
Low	X<M-SD	X<44	5
Medium	M-SD<=X<M+SD	44≤X<66	75

High	M+SD<=X	66≤X	35

The research subjects were divided into three groups, and the researcher used a purposive sampling technique to choose two students from each group based on *sociomathematical norms* to work on a test of mathematical representational ability that included up to five questions using material from linear programming. Then, in table 4, six students who are the focus of this study are listed.

Tabel 4. Research Subject Data

No.	Student Code	Score	Category
1	T-1	76	High
2	T-2	73	High
3	S-1	66	Medium
4	S-2	64	Medium
5	R-1	43	Low
6	R-2	42	Low

The researcher conducted an examination of the findings of the descriptive test of mathematical representation ability after choosing the six students who would be the study's subjects. The three markers of mathematical representation abilities can be mastered by T-1 student, but there are a few mistakes in symbolic representation. T-1 student can graphically describe the provided mathematical model for question number 1. By turning mathematical models into images, it demonstrates that T-1 student has mastered the visual representation indicator. Examine image 1.

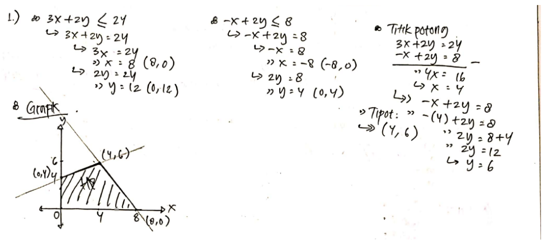


Image 1. Answer of Student T-1 Number 1

Student T-1 was able to solve the problem for question number 2, but made a small error while turning the graph into a mathematical model. Instead of writing the inequality as less than equal to (≤), student T-1 typed equal to (=). During the interview, student T-1 claimed that the error resulted from T-1's lack of caution when building mathematical models from the provided graphs because T-1 was too focused on solving mathematical issues. It demonstrates that T-1 student is not adept at translating visuals into mathematical models for use in mathematical issues. Examine image 2.

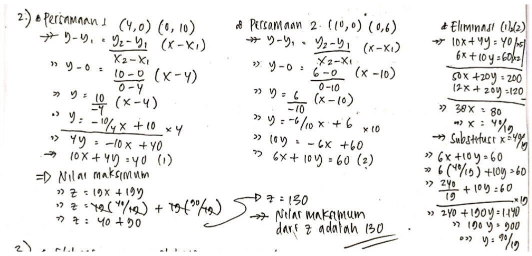


Image 2. Answer of Student T-2 Number 2

In Soal No. 3, Siswa T-1 is capable of understanding the topic at hand and is able to clearly present a mathematical model derived from a mathematical problem. This indicates that the T-1 student is using a symbolically-based indicator to create a mathematical model that is symbolically-based while solving mathematical problems. Remember image 3.

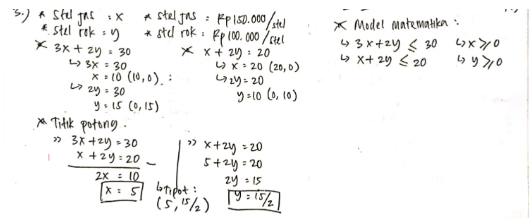


Image 3. Answer of Student T-1 Number 3

T-1 student can solve problems and accurately represent mathematical problem graphs for question number 4. This demonstrates that T-1 pupil is capable of creating visual representations of mathematics issues. Examine image 4.

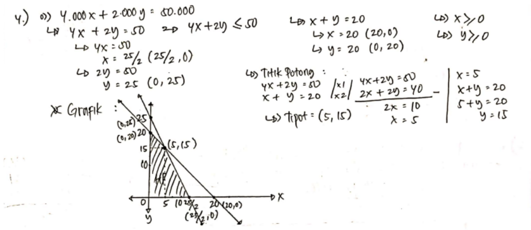


Image 4. Answer of Student T-1 Number 4

For question number 5, T-1 student can solve the problem and verbally represent the representation given. This shows that T-1 student master verbal representation indicators: formulating mathematical problem solving with words. Look at Figure 5.

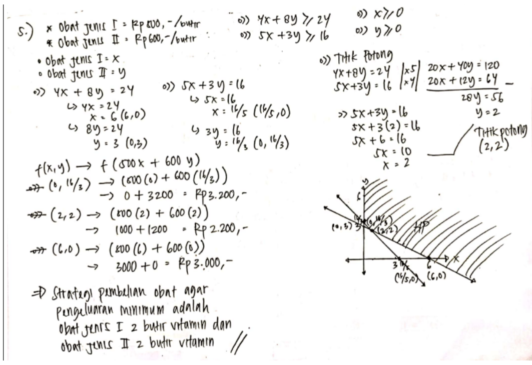


Image 5. Answer of Student T-1 Number 5

The three indications of mathematical representation abilities can be mastered by T-2 student with a high degree of *sociomathematical norms*, however there are flaws in symbolic representation. T-2 student can graphically represent the above mathematical model in question number 1. The ability to turn mathematical models into images demonstrates that T-2 student have mastered the visual representation indicator. View Image 6.

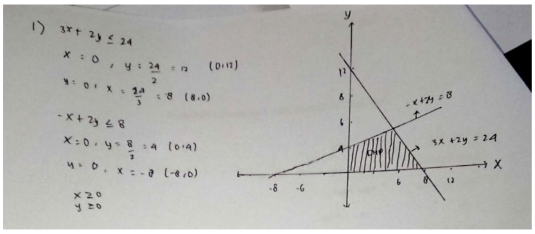


Image 6. Answer of Student T-2 Number 1

T-2 student can correctly answer mathematical issues and translate them from a provided graph into a mathematical model for question number two. This demonstrates that T-2 student is capable of solving mathematical issues by turning visuals into mathematical models. Examine image 7.

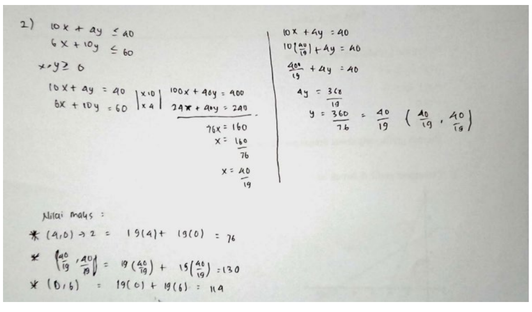


Image 7. Answer of Student T-2 Number 2

For question number 3, T-2 student is capable of correctly resolving mathematical issues, however there are a few instances where he fail to create comprehensive mathematical models. During the interview process, the T-2 student said that the masters students had solely been concerned with employing elimination and substitution techniques to solve problems. This demonstrates that T-2 student is not proficient at creating mathematical models symbolically while resolving mathematical issues. View image 8.

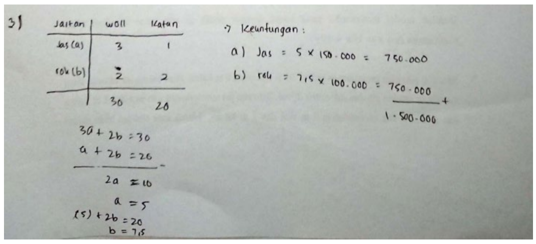


Image 8. Answer of Student T-2 Number 3

T-2 student can appropriately express mathematical problem graphs and solve problems for topic. This demonstrates that T-2 student is capable of creating visual representations of mathematics issues. View image 9.

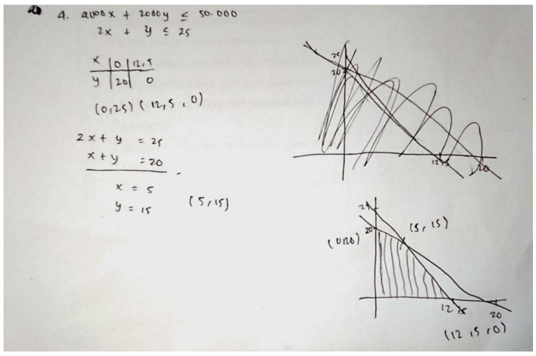


Image 9. Answer of Student T-2 Number 4

In response to question number 5, T-2 student can verbally describe addressing problems using the provided representation. The ability to express mathematical problem-solving in words demonstrates that T-2 student has mastered verbal representation indications. View image 10.

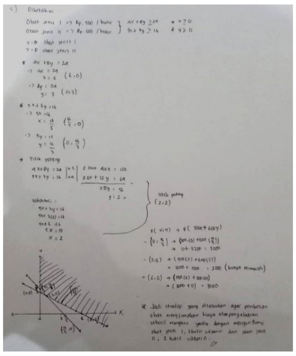


Image 10. Answer of Student T-2 Number 5

Two markers of the capacity for mathematical representation are mastered by S-1 student with a modest degree of *sociomathematical norms*. The two markers are symbols for both visual and symbolic representation. Undergraduate student, however, are only able to successfully accomplish one point in the visual representation indicators, namely the visual representation: turning mathematical models into images. S-1 student can successfully solve the problem for question number one. S-1 student is able to visualize a given mathematical model as a graph. This demonstrates that undergraduate students are adept at translating mathematical models into visual representations. Examine image 11.

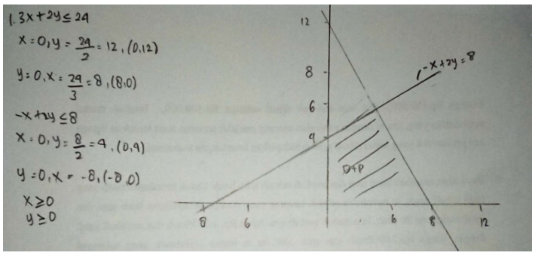


Image 11. Answer of Student S-1 Number 1

Student S-1 may effectively solve mathematical problems and translate them from a given graph into a mathematical model for problem number two. This demonstrates that student S-1 is capable of transforming visual representations into mathematical models for use in mathematical issues. View image 12.

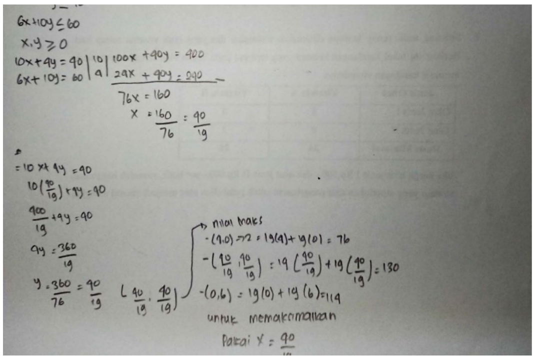


Image 12. Answer of Student S-1 Number 2

In question number 3, student S-1 can find solutions to mathematical problems and represent the mathematical model of mathematical problems correctly. This shows that student S-1 master the indicators of symbolic representation: making mathematical models symbolically in solving mathematical problems. Look at image 13.

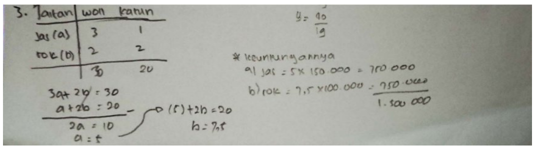


Image 13. Answer of Student S-1 Number 3

In the interview session, S-1 student explained that with regard to question number 4, he had trouble identifying the inequality in the presented problem, which made it difficult for him to create the necessary graph. Due to processing time constraints, students S-1 is unable to answer question number 5

Two markers of the capacity for mathematical representation are mastered by S-2 student with a modest degree of *sociomathematical norms*. Visual representation and symbolic representation serve as the two markers. However, master's degree student is only able to accomplish one point in the visual representation indicator, which is visual representation: turning a mathematical model into an image. Working on the symbolic representation indicator question contained a mistake. S-2 student can successfully answer the first question. S-2 student is able to visualize a given mathematical model as a graph. Making mathematical models into images demonstrates the mastery of visual representation indicators among master's degree candidates. View image 14.

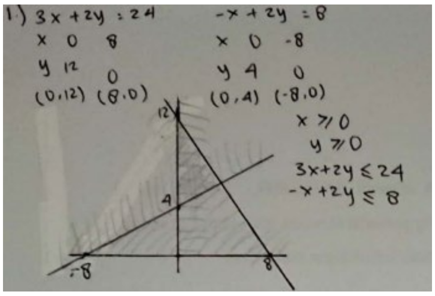


Image 14. Answer of Student S-2 Number 1

For question number 2, S-2 student can work on mathematical problems correctly and represent them from a given graph in the form of a mathematical model. This proves that undergraduate students master the indicator of symbolic representation: converting images into mathematical models in mathematical problems. Look at image 15.

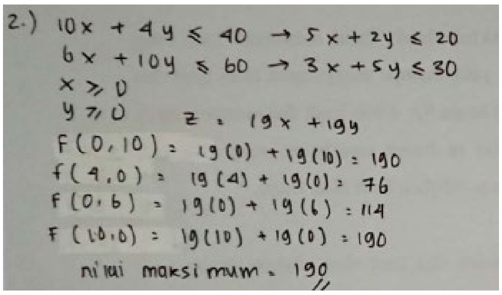
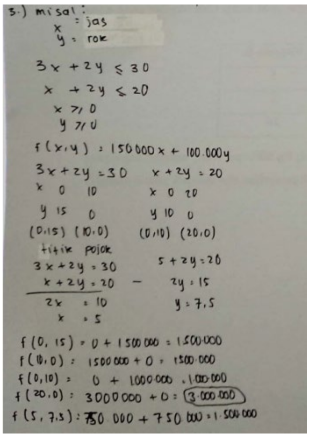


Image 15. Answer of Student S-2 Number 2

When trying to solve question number 3, S-2 student makes mistakes, although he can accurately depict a mathematical problem's model. During the interview session, S-2 student claimed that because S-2 student determined the set point of completion incorrectly, S-2 student made mistakes when attempting to solve mathematical problems. The ability to create mathematical models symbolically when addressing mathematical issues demonstrates the mastery of symbolic representation indicators among master's degree students. Take a look at image 16



Gambar 16. Answer of Student S-2 Number 3

During the interview session, the student S-2 explained that due to a lack of time to complete the soal, he was unable to present topics 4 and 5. Therefore, Student S-2 is unable to provide any kind of feedback.

Two indices of the capacity for mathematical representation are mastered by R-1 student with a modest degree of *sociomathematical norms*. Visual representation and symbolic representation serve as the two markers. However, for each of the two indications, only one point—visual representation, or turning mathematical models into images, and symbolic representation, or turning mathematical models into images in mathematical problems—covers both points. The first question was successfully answered by student R-1. Student R-1 may see the provided mathematical model as a graph. It demonstrates that the visual representation indication, which involves turning mathematical models into images, was mastered by pupils in R-1. Observe image 17

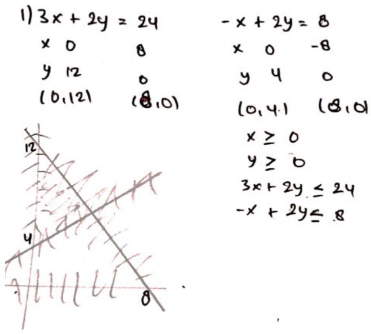


Image 17. Answer of Student R-1 Number 1

Student R-1 can solve mathematical problems correctly and represent the mathematical model from a given graph for question number 2. This demonstrates that student R-1 is capable of solving mathematical issues by turning visuals into mathematical models. View image 18.

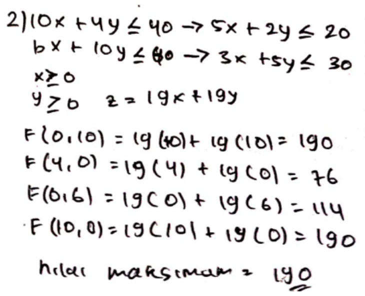


Image 18. Answer of Student R-1 Number 2

Student R-1 admitted during the interview that she found it challenging to answer questions 3, 4, and 5. Student R-2 found it challenging to create a symbolic mathematical representation of a mathematical problem in question number 3. Due to a lack of time, pupils in R-1 are unable to complete questions 4 and 5's problems

One measure of the capacity for mathematical representation, called symbolic representation, is mastered by R-2 student with a modest degree of *sociomathematical norms*. Only one concept, symbolic representation—creating mathematical models symbolically—can be mastered by student R-2 in order to solve mathematical issues Student in R-2 was able to depict the mathematical model of the provided mathematical problem in question 3, but they were unable to come up with a solution. View image 19.

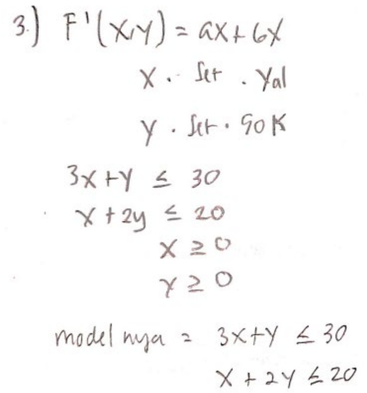


Image 19. Answer of Student R-2 Number 3

During the interview session, student R-2 said that for question number 1, student R-2 could not make a graph according to the mathematical model given. In question number 2, students R-2 explained that students R-2 had difficulty converting graphs into mathematical models. In question number 4, students R-2 had difficulty making a graph of a mathematical problem. In question number 5, students R-2 do not understand how to solve mathematical problems on the problem.

The findings of the data analysis of mathematical representation abilities in terms of *sociomathematical norms* demonstrate that students who have a high level of *sociomathematical norms* can be active when learning mathematics, accept and explain arguments mathematically, compare equations and differences in arguments, and find efficient solutions in solving problems that have an impact on mathematical abilities that students have in learning mathematics where students can. This is consistent with Aslamiah's (2018) research findings, which demonstrate the link between effective *sociomathematical norms* and successful mathematics learning outcomes. The analysis's findings in this study therefore make it easier to perform in-depth research on high-level *sociomathematical norms* on other subjects.

Students with a moderate level of *sociomathematical norms* are able to accept a variety of ideas and arguments during class discussions as well as ideas and arguments submitted by their peers, but they struggle to communicate their own ideas and arguments. capable of comprehending what is being taught by the teacher and being able to come up with answers to issues, but frequently commit negligence by neglecting to check the stages of solving mathematical problems that have already been finished. have an effect on students' mathematical ability in mathematics classes where there are minimal difficulties for students to overcome when expressing their ideas and concepts in a particular form. This is consistent with study by Salim & Maarif (2021), which demonstrates that sociomathematical norms have an impact on the results of mathematics learning. In order to perform in-depth research on moderate-level *sociomathematical norms* on various issues, the results of this study help additional research.

Low sociomathematical normative students tend to be less engaged in their studies, struggle to articulate their ideas and arguments, have a hard time understanding what their teachers are trying to explain, and don't look for alternative solutions when solving mathematical problems. This has an effect on their mathematical ability. that kids experience when learning mathematics and having trouble expressing their thoughts and ideas. This is consistent with the findings of Ningsih & Maarif's research, which indicated that pupils who have low *sociomathematical norms* will also have bad learning outcomes. As a result, if you want to do in-depth research on low-level *sociomathematical norms* on other issues, the results of this study enable it.

According to the definition of mathematical representation ability in terms of sociomathematical norms, T-1 and T-2 students who meet all criteria for mathematical representation ability are said to have good mathematical representation abilities. Students in S-1 and S-2 with moderate *sociomathematical norms* have some issues with their capacity to represent mathematical ideas by satisfying both markers. By meeting a few of the indicators of mathematical representation abilities, students R-1 and R-2 with low *sociomathematical norms* have low representational abilities. The findings of this study are consistent with those of Ningsih & Maarif's study, which found a strong correlation between students' *sociomathematical norms* and learning outcomes, one of which is the degree of mathematical proficiency with which students are able to solve problems.

Conclusion

According to the research, sociomathematical norms and mathematical representation skills are related, and students who exhibit high levels of *sociomathematical norms* are able to work on problems and meet all requirements for mathematical representation skills. Students who meet two of the three indications of mathematical representation ability can work on some problems and have modest *sociomathematical norms*. One of the three indications of mathematical representation ability is challenging for students who have poor *sociomathematical norms* to complete.

According to the inferences drawn from the research's findings, pupils' capacity for mathematical representation increases in direct proportion to the quality of their *sociomathematical norms*. In a similar vein, students' capacities for mathematical representation decline in proportion to how low their *sociomathematical norms*. Because there was no prior research on the analysis of mathematical representation abilities in terms of *sociomathematical norms,* this formulation can be a new research finding.

The analysis of this study is still restricted to class XI SMAN 105 Jakarta students who have access to linear programming material. As a result, the researcher offers recommendations for additional research that will focus more intently on the ability of mathematical representation in terms of aspects of *sociomathematical norms* at other levels and materials, and uses this research as a guide for creating both those abilities and norms.

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