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STUDENTS' MATHEMATICAL REPRESENTATION ABILITY IN LEARNING OF MATHEMATICAL MODELING USING ANDROID-BASED LEARNING MEDIA

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Abstract

Mathematical representation ability is one of the important mathematical abilities for students to have because this ability plays an important role in students' ability to solve problems. This research is a descriptivequalitative research that aims to see students' mathematical representation skills in learning mathematical modeling using android-based learning media. The instruments used in this study were test questions in the form of mathematical modeling essay questions and interview guidelines. Students' mathematical representation ability was measured based on indicators of mathematical representation ability, namely visual representation, mathematical expression representation, and verbal representation. Based on the results of data analysis, it was concluded that the representation ability of students had a Very Good category of 63%, a Good category of 20%, and a Fair category of 17%. Students with Very Good category can do mathematical representation well as a way to help them in doing problem solving. Most of students in the Good category can make mathematical representations well, but still make a few mistakes in counting and understanding the problem. Most of students in the Fair category can make visual representations, but have not been able to do mathematical expression representations or verbal representations optimally.

Keywords: mathematical representation ability; mathematical modelling; android-based learning media

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1. Introduction

One of the most important subjects for students to learn at school is mathematics (Rahmah, 2018). To support their understanding of mathematics, students need to have good mathematical skills (Ariawan & Nufus, 2017; Kartini, 2009; Kusumawardani et al., 2018). One of these mathematical abilities that plays an important role in understanding mathematics is mathematical representation ability (Fitrianingrum & Basir, 2020). Mathematical representation ability relates to proficiency in using symbols, tables, diagrams, or other alternate formats to express mathematical ideas and conduct mathematical modeling (NCTM, 2000). This includes the ability to change one representation form to another and choosing the most appropriate form to solve the problem. (Supriadi & Ningsih, 2022). According to Nur et al. (2020), the ability to represent mathematically is very important for students in solving mathematical problems because it allows students to represent complex ideas and thoughts in a simpler way. A student with good mathematical representation ability will find it easier to model a problem into a mathematical model and develop a solution based on the model (Sari & Ralmugiz, 2020). But if students have low mathematical representation skills, then the students' mathematical understanding, which functions as a problem solving tool, will be hampered (Azizah et al., 2019).

However, there are still many students who have difficulty in doing mathematical representations, such as making pictures, graphs, tables, diagrams, and others (Khusna & Ulfah, 2021). This is also evident from Indonesia's PISA results which show that students in Indonesia can only do math problems at low levels, namely level 1 and level 2 (OECD, 2019). The indicator for level 2 questions is that students can interpret and recognize, without giving direction to a situation that can be represented mathematically (Mulyaningsih et al., 2020). The low mathematical representation ability of students in Indonesia can be caused by the limited ability of teachers in teaching and learning mathematics that's still done conventionally (Hudiono, 2010). This has an effect to the development of students' mathematical representation ability (Hudiono, 2010). Therefore, the right learning approach is needed to help the development of students' mathematical representation skills.

Based on research done by Choiriyaza (2017), learning activities using a mathematical modeling approach can improve students' mathematical representation skills. Mathematical modeling learning is a learning activity that involves techniques to describe or represent a problem that exists in daily life into a mathematical model (Ndii, 2022). Mathematical modeling learning allows students to connect every mathematical representation that has been made by students (symbols, images, graphs, diagrams) into a solution to the problem. So we can conclude that mathematical modeling learning can improve students' mathematical representation skills (Khusna & Ulfah, 2021; Suwanto et al., 2017).

One of the mathematic topics that's difficult for students to understand in mathematical modeling learning is statistics (Junika et al., 2020). Based on research done by Awaludin (2017), students did not understand how to use the formula of mean, median, mode, and the meaning of the variables in the formula. To deal with these difficulties, teachers need to use a better learning strategy, such as using learning media that is effective, attractive, and interactive (Nurrita, 2018; Wulandari, 2019). Teachers can use technology such as android as a learning media. Android-based learning media has become one of the interesting solutions to help students understand the taught lessons (Heswari & Patri, 2022). That's because android-based learning media is developed to improve the quality of learning by breaking through time and space limitations (Darmawan, 2016). Android-based learning media is also flexible, so students can easily access it anywhere and anytime if they have difficulties during the learning process in class (Amirullah & Hardinata, 2017). With the android-based learning media, students can also be more independent, comfortable, and not pressured because students are used to using android in their daily lives (Setiawan, 2017). Thus, android-based learning media will be very useful if used properly in the learning activities.

Based on research done by Ilmi & Wulandari (2022), shows that android-based learning media can facilitate students to represent something, especially in geometry topic, so it's recommended to do other research related to representation ability. There is another study from Sulastri et al. (2017) which also examined students' mathematical representation ability but it was conducted using the PMRI approach. Some research related to mathematical representation ability in learning using android-based media has been done (Awanis, n.d.; Delisbeth et al., n.d.; Maulana, 2019), but not many studies have discussed students' representation ability in learning of mathematical modeling using android-based learning media.

Starting from the explanation that has been conveyed previously, the researcher would like to research the topic with the title *"Students' Mathematical Representation Ability in Learning of Mathematical Modeling Using Android-Based Learning Media"*.

2. Method

This study is a descriptive qualitative study that aims to describe students' mathematical representation skills in learning of mathematical modeling using android-based learning media. The participants of this study were high school students XII IPA 2 of SMAN 01 Palembang in the 2023/2024 school year consisting of 30 people. The indicators used to measure students' mathematical representation ability are as follows.

Table 1. Indicators of Mathematical Representation Ability

Indicators	Descriptors
Visual Representation	
Student be able to change, present, and rewrite data or information that has been obtained from a problem in the form of diagrams, graphs, geometric images, or tables.	• Converting raw data or information from a given problem into an appropriate visual representation, such as diagrams, graphs, geometric figures, or tables, ensuring accuracy and clarity. • Representing the data or information in the form of a visual representation (table, histogram, or diagram)
Mathematical Expression Representation	
Students be able to solve a problem by using the mathematical expressions, such as algebraic equations or symbols.	• Rewrite the problem in the form of symbols or mathematical equations. • Using mathematical equations or symbols to solve a problem
Verbal Representation	
Students be able to explain and describe the solution to a problem clearly and logically through written text or words.	• articulate the steps and reasoning used to solve a problem in a structured and coherent manner, ensuring that the explanation follows a logical sequence. • Describe the solution accurately using precise language, avoiding ambiguity, and ensuring that the written or verbal explanation is easily understandable.

The android-based learning media that used in this research as following:

Figure 1. Learning media

The instruments in this study were test questions and interview guidelines. The instruments have been validated by experts, which are two experts who are lecturers in the study program of mathematics education at Sriwijaya University and one mathematics teacher of SMAN 01 Palembang. Test questions are used to collect data on students' mathematical representation ability on the topic of central tendency in the learning of mathematical modeling using android-based learning media. The test questions used are essay questions on mathematical modeling with the topic of central tendency. While interviews were used to obtain more accurate and clear data from research subjects about mathematical representation ability. The interview subjects were one person from each category of mathematical representation ability. The determination of the ability category is based on the score of the test results after the implementation of mathematical modeling learning using android-based learning media. The categories of mathematical representation ability used in this study are as follows.

Table 2. Indicators of Mathematical Representation Ability

Score	Categories
$0 \leq score \leq 20$	Very Weak
$20 < score \leq 40$	Weak
$40 < score \leq 20$	Fair
$60 < score \leq 80$	Good
$score > 80$	Very Good

This research analyzes the data from the written test results based on the guidelines of scoring tests and analyzes the interview data in the form of voice recordings when conducting interviews.

3. Results and Discussion

At the end of the learning activities with the mathematics modeling approach using android-based learning media. the subjects were asked to work on test questions that had been presented in the learning media. The test questions are as follows.

Figure 2. Test Question Number 1

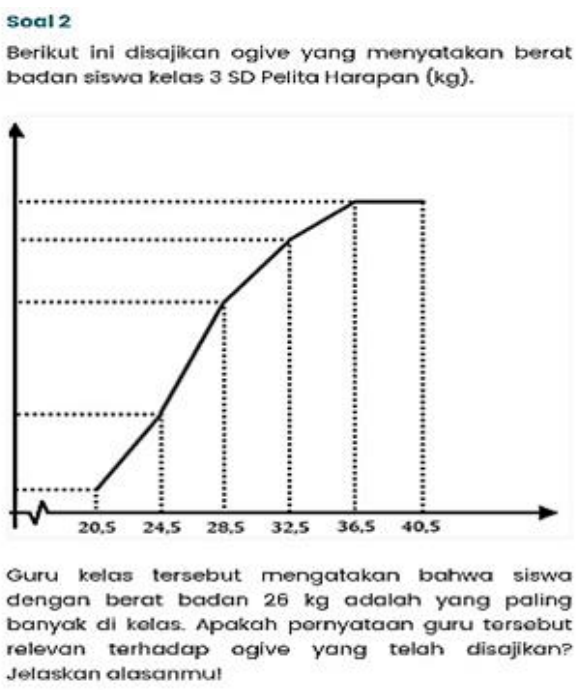


Figure 3. Test Question Number 2

Figure 4. Test Question Number 3

The test results that have been done by the subject will be analyzed and given a score based on the scoring guidelines for the test questions. Furthermore, based on the results of scoring the test questions, the researcher will determine the category of mathematical representation ability of each subject. The categories of mathematical representation ability are presented as follows.

Table 3. Results of Analysis of Students' Mathematical Representation Ability

Categories of Students' Mathematical Representation Ability		
Categories	**Amount**	**Percentage**
Very Good	19	63%
Good	6	20%
Fair	5	17%

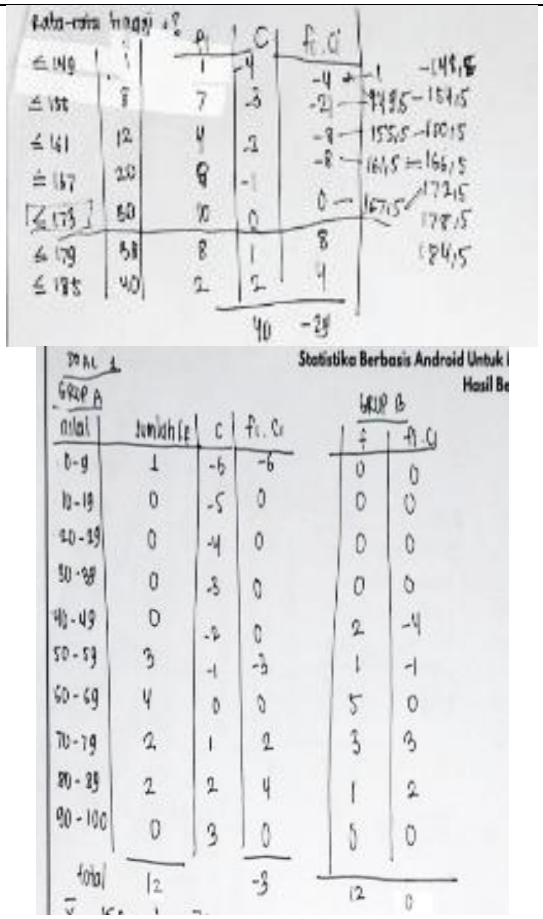
Based on the table, 1 student from each category will be selected to be used as a sample representing each category of mathematical representation ability and also to be interviewed regarding the results of the test questions they have done. The three students who have been selected are DR (student with Very Good category), PB (student with Good category), and RS (student with Fair category).

3.1 Subject DR

Table 4 presents the results of the analysis of DR's answers.

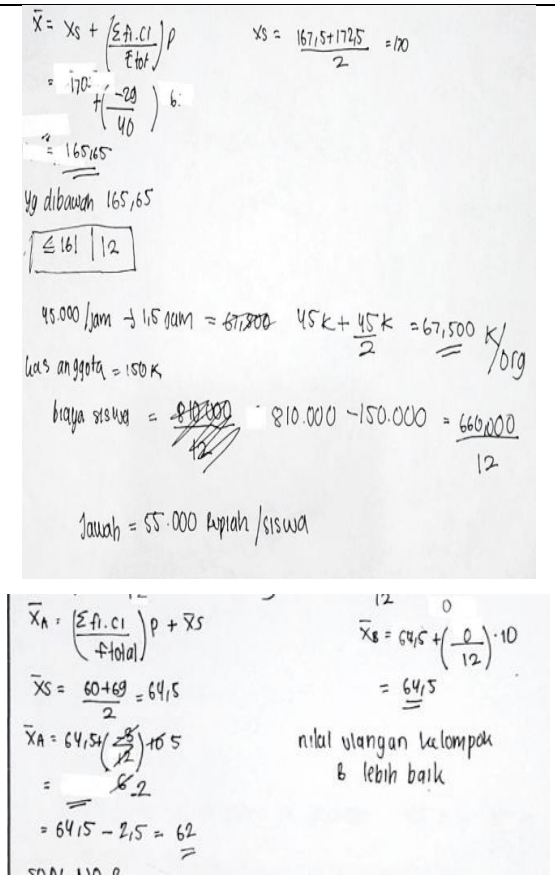
Table 4. Analysis of Subject DR's Answer

Visual Representation



The given histogram and relative frequency distribution table were transformed into a fully articulated frequency distributable, which subjected DR to significant proficiency in data transformation. Several layers of analytical and technical expertise were necessary for this process. The initial step was for Subject DR to carefully interpret the graphic data from the histogram, extracting crucial details like class intervals, frequency densities, and distribution patterns with precision. The relative frequency table accounted for the relationship between percentages or proportions and absolute values. Subsequently, Subject DR utilized appropriate statistical techniques to reconstruct the information into a frequency distribution table, including setting clear class boundaries, calculating absolute frequencies, and labeling categories correctly (e.g, "Class Interval," "Frequency "). Additionally, Subject DR organized the new table in this manner, making comparisons to the original figures easier.) Subject DR's proficiency in representing information in different formats (graphical, numerical, tabular) is demonstrated through her statistical literacy, attention to detail, and ability to present information accurately and consistently in various forms depending on analytical needs. These skills are essential in research, data analysis, and evidence-based reporting, where multi-format data representation improves the clarity and accessibility for diverse audiences

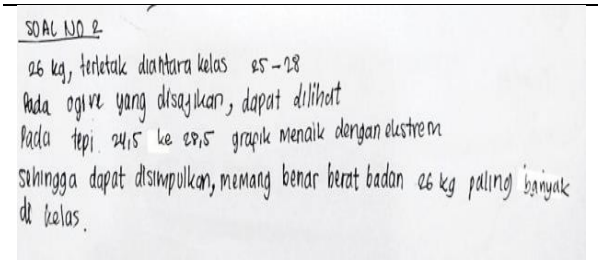
Mathematical Expression Representation



The ability of Subject DR to bridge the gap between conceptual understanding and analytical execution was demonstrated through her successful mathematical reasoning, which translated the given problem into precise mathematical expressions. The task was to identify the essential variables, parameters, and relationships within the problem, then express them in equations, inequalities, or functions that correctly modeled the situation. Subject DR not only constructed these expressions correctly, but also utilized appropriate mathematical techniques such as algebra, calculus-based optimization, or logical deduction to arrive at meaningful solutions. Yo arrive at A solution that was finally justified by logical reasoning. In addition, Subject DR verified the accuracy of outcomes by cross-examining computations or contextualizing answers within the constraints of the problem, ensuring both mathematical and practical correctness. This skill requires a deep understanding of mathematical abstraction and practical problem-solving.

Verbal Representation

The solution was communicated clearly by subject DR through written explanation. ". The answer was constructed in a clear and concise manner, with precise mathematical terminology and the ability to justify every step of the logic.


SOAL NO 2
26 kg, terletak diantara kelas 25 - 28
Pada ogive yang disajikan, dapat dilihat
pada titi 24,5 ke 29,5 grapik menaik dengan elustrem
sehingga dapat disimpulkan, memang benar berat badan 26 kg paling banyak
di kelas.

The conclusion that can be drawn from the analysis of subject DR is that subject DR has fulfilled the three indicators of mathematical representation ability very well, so that the mathematical representation ability of subject DR is categorized as very good. This can be seen from the DR subject's ability to re-represent the data or information in the other representation forms, represent problems in the form of mathematical expressions and use them to solve problems, and write explanations about the answers written in words. This is in accordance with the research of Sulastri et al. (2017), which states that students with high mathematical representation ability category can fulfill all indicators of mathematical representation ability.

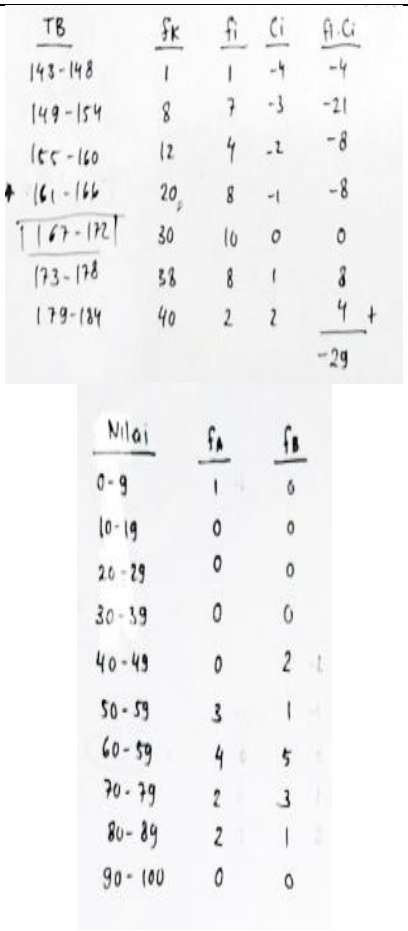
According to the interview with subject DR, it was found that subject DR did not find it too difficult to do mathematical representations, whether it was visually, mathematical expressions, or verbally. Subject DR felt that using mathematical representations could help subject DR in solving problems, so it makes DR used to using mathematical representations in problem solving. This is in line with the research done by Sulastri et al. (2017), which states that students with high mathematical representation ability are used to using mathematical representations in problem solving.

3.2 Subject PB

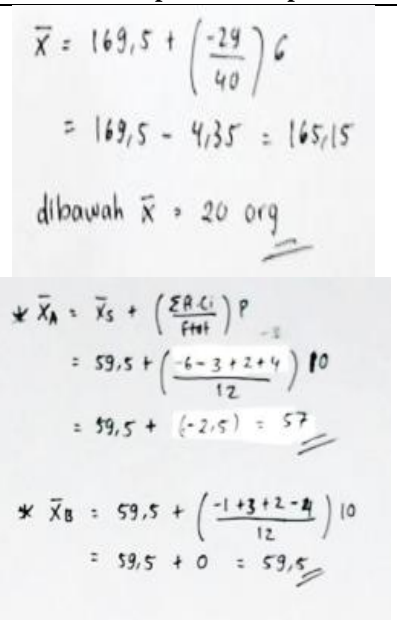
Table 5 presents the results of the analysis of subject PB's answers.

Table 5. Analysis of Subject RS's Answer

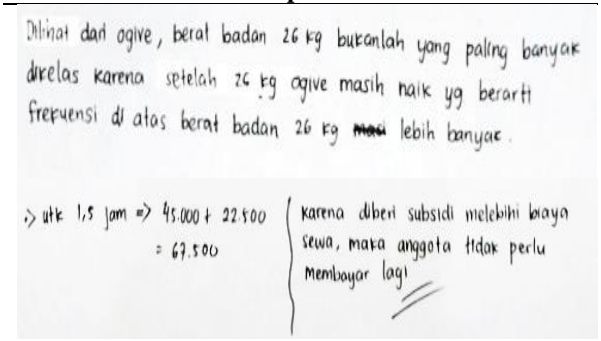
Visual Representation
By effectively converting the provided histogram and relative frequency distribution table into a comprehensive frequency Distribution Table, Subject (PB) demonstrated proficient data transformation skills. The task involved several mental processes: PB had to first accurately interpret the graphic information from the histogram, identifying class intervals and their frequency frequencies. PB's accurate conversion of proportional values to absolute frequencies is evident in the relative frequency table. Consistent class widths, proper labeling of intervals and numerical accuracy in frequency counts were statistically important during the conversion.


TB | fk | fi | Ci | fi.Ci
143-148 | 1 | 1 | -4 | -4
149-154 | 8 | 7 | -3 | -21
155-160 | 12 | 4 | -2 | -8
161-166 | 20 | 8 | -1 | -8
167-172 | 30 | 10 | 0 | 0
173-178 | 38 | 8 | 1 | 8
179-184 | 40 | 2 | 2 | 4 +
-29

Nilai | fA | fB
0-9 | 1 | 6
10-19 | 0 | 0
20-29 | 0 | 0
30-39 | 0 | 0
40-49 | 0 | 2
50-59 | 3 | 1
60-69 | 4 | 5
70-79 | 2 | 3
80-89 | 2 | 1
90-100 | 0 | 0

Mathematical Expression Representation
 Subject PB's comprehension of the problem was enhanced by their ability to accurately translate it into relevant mathematical expressions, effectively representing the underlying relationships and variables. Their work consisted of formulating equations or models that accurately portrayed the problem's structure, demonstrating their proficiency in translating abstract situations into mathematical language. However, PB did make some computational mistakes during the execution stage that resulted in slight errors within the final solution.

Verbal Representation



Subject PB's response was structured and concise, as she could articulate their solution and reasoning. The way they responded was through using logical logic and relevant mathematical terms, suggesting an effort to make their reasoning clearer. However, the interpretation also uncovered gaps in conceptual understanding, with some of the problem being mistranslated or inaccurately explained. Despite the fact that PB was capable of organizing their explanation into coherent steps, such as revising the problem, outlining their strategy, and presenting their conclusion, there were instances where the reasoning didn't always adhere to mathematical requirements for the task. PB may need to be reinforced in connecting theoretical concepts to their practical applications, as indicated by these flaws. The effort to justify their response in writing demonstrates improved communication skills and an understanding of the significance behind explaining mathematical reasoning.

The conclusion that can be drawn from the analysis of Subjek PB's answer is that Subject PB fulfilled the three indicators of mathematical representation ability, but there were some mistakes in the indicators of mathematical expression representation and verbal representation. Therefore, the representation ability of PB subjects can be categorized as Good. This is in line with the research done by Hardianti & Effendi (2021), which states that students with moderate mathematical representation ability have fulfilled all three indicators of mathematical representation ability, but there are some mistakes in each indicator.

Based on the interview with subject PB, it was found that subject PB could more easily do problem solving by using mathematical representation. For questions number 1 and 3, subject PB said that the subject could better understand histograms and relative frequency distribution tables in the form of frequency distribution tables usually learned at school. Subject PB said that she often felt rushed when working on test or exam questions, so the subject sometimes made mistakes when understanding the questions and doing mathematical calculations. The information from the interview also showed that the subject PB did not really understand the ogive in question number 2, so the answer written by the subject PB was wrong. This is in line with research conducted by Mulyaningsih et al. (2020), that the lack of student understanding of the problem leads to errors in making mathematical representations.

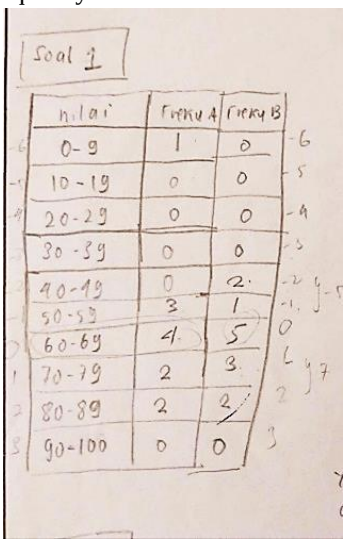
3.3 Subject RS

Table 6 presents the results of the analysis of subject RS's answers.

Table 6. Analysis of Subject RS's Answer

Visual Representation

In question number 1, Subject RS demonstrated their ability to interpret and transform graphical data into a structured tabular format, partially due to their successful conversion of the histogram into an accurate frequency distribution table.

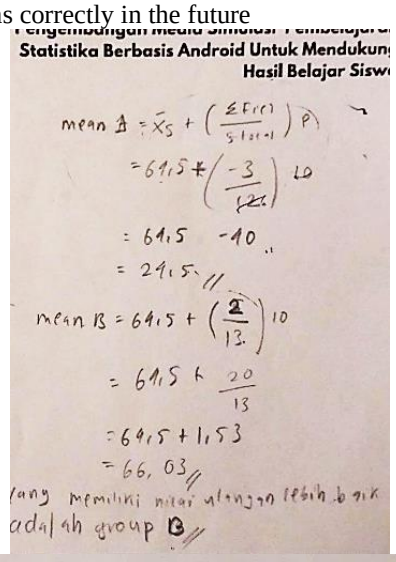


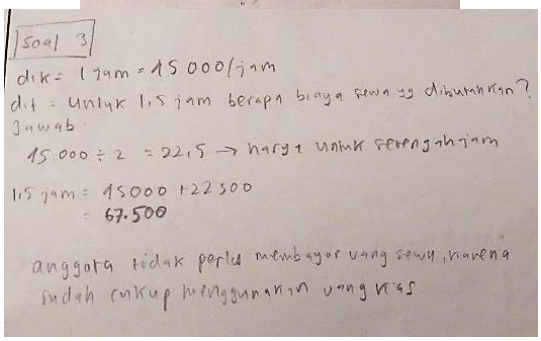
Despite this, the skill was not consistently utilized, as RS was unable to convert the cumulative frequency distribution table in question 3 into an ogive or relative frequency table. This is noteworthy. The dissimilarity indicates that RS is familiar with basic data transformation methods, but may require additional practice with different statistical models. Their performance on these two questions differs, suggesting that they could be improved in terms of applying these skills uniformly to different problem types.

Mathematical Expression Representation

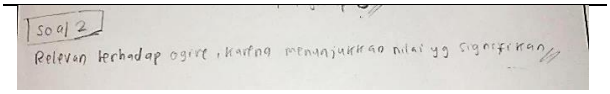
The ability of Subject RS to translate the given problem into mathematical expressions and use them to solve it was an example of fundamental skills in mathematical modeling and problem-solving. However, their resolution also contained faults arising from both incomplete understanding of the problem's requirements and inaccuracies in carrying out the calculations. RS's errors suggest that they must not solely grasp the general method of creating mathematical problems, but rather improve their

comprehension of problem details and computational accuracy. A focused effort to carefully interpret word problems and verify intermediate calculation steps could enhance the precision of RS. Also, revisiting fundamental concepts concerning the type of problem would enable them to set up and solve comparable problems correctly in the future





Verbal Representation



Despite her answer, Subject RS found it challenging to provide a comprehensive written explanation, indicating poor communication skills. There was no elaboration, rational explanation or appropriate terminology in her response to explain the steps she took on that particular issue. This implies a requirement to improve mathematically significant written communication skills, especially in linking conceptual understanding to explanatory language.

The conclusion that can be drawn from the analysis of the RS subject is that the RS subject fulfills two of the three indicators of mathematical representation ability. But there were still some mistakes in representing mathematical expressions and Subject RS did not explain more clearly on the verbal representation indicator. In question number one, subject RS can re-represent the histogram in the form of a table. But when doing mathematical calculations, subject RS made some miscalculations. Then for question number 2, subject RS already has the right answer but subject RS did not write clearly about the answer she wrote. This is in accordance with the research of Mulyaningsih et al. (2020), which states that students who cannot give the right conclusion or explanation, does not fulfill the verbal representation indicator. Then for question number 3, subject RS did not understand the problem well, so that the answers were not what the researcher wanted. This is in line with research conducted by Mulyaningsih et al. (2020), that students' lack of understanding of the problem resulted in errors in solving the problem.

From the interview with subject RS, it was found that subject RS can more easily understand the histogram by representing it first in the form of a table. For question number 1, subject RS said that she felt rushed when working on the problem, so that there was some miscounting. Then for question number 3, subject RS said that she forgot to find the average height of the basketball players, so she felt no need to re-represent the relative frequency distribution table presented in the problem. Then for question number 2, subject RS said that she also felt that her answer was wrong because she thought that the most was the weight of 40 kg. This shows a lack of understanding of the concept, making the RS subject unable to write the answer correctly. Similar to the study done by Marliani & Puspitasari (2022) that students' difficulties in doing mathematical representations can be caused by students' inability to understand the problems given.

In general, based on the results of the analysis that has been presented and the analysis that has been carried out on all the answers of students who have participated in mathematical modeling learning using android-based learning media, it is known that students' mathematical representation skills have a very good category of 63%, a good category of 20%, and a sufficient category of 17%. This shows that students' mathematical representation skills in learning modeling using android-based learning media are good. This is in line with the research of Sulastri et al. (2017), which states that students' mathematical representation skills through the PMRI approach as a whole have reached a good category. Then from the analysis of the results of the subject's test answers, it can be seen that most students can create and use visual representations properly and correctly, to help them in analyzing data and solving problems. This is in line with the research of Yais & Mega (2021), which states that students can more easily solve problems if these students can do visual representations properly and

correctly. Some errors are still commonly found in representing mathematical expressions and verbal representations. Factors that influence these errors are mostly caused by students' lack of understanding of the problem.

Students in the Very Good category do not have difficulties in making mathematical representations as a part of their solution to problems. That is because they already become used to doing mathematical representations when solving a problem. Then, most students in the Good category can do mathematical representations well as a way for them to make it easier to solve problems. Students with Good ability category are able to represent data, information, or problems into other forms of representation, but they still make a few mistakes in calculating and understanding the problem. Most of the students in the Fair category have fulfilled 2 out of 3 indicators of mathematical representation ability. Most students in the Fair category are able to do visual representations, but have not been able to do mathematical expression representations or verbal representations optimally. This is because students in the Fair category can not understand the problem properly, so that the mathematical representations they made are going wrong.

There are some ways that could be done to maximize students' mathematical representation skills, one of them is by implementing mathematical modeling learning. Mathematical modeling is a technique used to represent and simplify a contextual problem into mathematical form (Ndii, 2022). It can be seen that mathematics modeling requires mathematical representation skills as one of its tools (Muthianisa & Effendi, 2022). Based on research done by Sulastri et al. (2017), Students with good mathematical representation ability will help them to describe and serve the information that has been collected into a mathematical representation, to solve the problem given. Meanwhile, students with weak mathematical representation ability will have difficulty in understanding the problem, representing information mathematically, and making mistakes when constructing solutions. This is also in line with the research by Muthianisa & Effendi (2022), which states that students with weak mathematical representation ability have difficulty when explaining and describing the mathematical problems given to them. This learning can also be maximized if it uses learning media that is attractive, effective, and interactive, such as android-based learning media. Based on previous research conducted by Nuraeni et al. (2020), it can be seen that mathematics learning using android-based learning media can improve students' mathematical representation skills compared to using conventional mathematics learning. Android-based learning media is flexible, so teachers can create learning media in various ways and features according to their needs. Android-based learning media can be designed as needed in classroom learning activities, so teachers must be more creative and innovative in designing learning media to achieve learning goals (Astuti et al., 2018)

According to the interview with subject DR, it was found that subject DR did not find it too difficult to do mathematical representations, whether it was visually, mathematical expressions, or verbally. Subject DR felt that using mathematical representations could help subject DR in solving problems, so it makes DR used to using mathematical representations in problem solving. This is in line with the research done by Sulastri et al. (2017), which states that students with high mathematical representation ability are used to using mathematical representations in problem solving.

4. Conclusion

Based on the analysis of students' mathematical representation ability after the implementation of mathematical modeling learning, it was concluded that the representation ability of XII IPA 2 students at SMAN 01 Palembang had a Very Good category of 63%, a Good category of 20%, and a Fair category of 17%. Students in the Very Good category have fulfilled all three indicators of mathematical representation ability, and been able to do mathematical representation well as a way to facilitate them in problem solving. Then most students in the Good category have fulfilled the three indicators of mathematical representation ability and been able to do mathematical representation as a way to make it easier for them to do problem solving. But students in the Good category made a few mistakes in calculating and understanding the problem. Then, most students in the Fair category have fulfilled 2 of the 3 indicators of mathematical representation ability. Most students in the Fair category have been able to do visual representations, but have not been able to do mathematical expression representations or verbal representations optimally.

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