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Students' Mathematical Modeling Ability in Solving Data and Uncertainty Questions on *Asesmen Kompetensi Minimum*

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Abstract: Mathematical modeling can help students to see the connection between mathematics and daily life. *Asesmen Kompetensi Minimum* (AKM) questions with a context ask students to answer everyday life mathematical problems. The purpose of this study is to establish the ability with which junior high school students in grade VIII can solve AKM problems using mathematical modeling. This type of research is descriptive research with a qualitative approach. The data described is the mathematical modeling ability of students in completing AKM. An assessment sheet with AKM questions specifically designed for the data and uncertainty content domain was distributed to the students in the numeracy part. In order to analyze the data, conclusions were made and the percentage of students who satisfied particular indicators of mathematical modeling were described. The results showed that in the data and uncertainty content domain, students' mathematical modeling abilities are quite diverse. 15% students are able to reach the stage of exposing and answering questions correctly. 85% of students are still unable to interpret and validate the answers obtained from working mathematically to be referred to the situation of daily life problems in the given problem. Teachers have an important part in helping students develop the habit of writing answers in a structured way so they can respond to questions with the appropriate answers.

INTRODUCTION

One of the aims of teaching mathematics in schools at every level is so that students can solve problems which includes the ability to understand problems, design mathematical models, solve the models or interpret the solutions obtained (Pusmenjar, 2020). Mathematical problems that arise in everyday life are closely related to mathematical modeling. mathematical modeling leads the students understand and use mathematics in the real world and see the connection between mathematics and the real world (Zulkarnaen, 2018). This makes students' modeling abilities important to develop. Mousoulides et al. (2008) added that students' modeling ability affects the way students solve modeling problems. This means that the better the students' modeling abilities, the better the students' mathematical problem-solving abilities, which will achieve the goal of teaching mathematics in schools. Therefore, in order to answer problems that are relevant to the real world and context-based mathematics, students must possess mathematical modeling ability.

With the aim for the mathematical modeling created to properly represent the problem, the ability to transform the real world into mathematical problems is a necessary component of the modeling process (Khusna & Ulfah, 2021). As a result, mathematical modeling is always derived from the real world, which can be explained by a model and utilized for solving problems. Modeling is the term used to describe this entire process (Greefrath & Vorhölter, 2016). In order to translate mathematical problems into the form of mathematical symbols and derive a solution, mathematical modeling skills are ultimately required.

The study carried out by Khusna & Ulfah (2021) showed that while students' abilities in the structural phase are still lacking, some students still struggle to understand word problems. The first phase in the modeling process that needs to be completed in order to obtain a solution is the compilation of mathematical models from the real world. The idea that word problem solving phases and students' mathematical modeling abilities are related suggests that both operate a mutually reinforcing role. Students can use their mathematical modeling skills to tackle word problems (Pandiangan & Zulkarnaen, 2021). Therefore, there is a connection between mathematical modeling and real-world problem solving.

According to Maulani et al., (2022), students are required to study the field of mathematics at every level, because in solving problems related to everyday life, students need the ability to understand and see the connection using mathematics. Therefore, one of the abilities that students must have and it has an important role in learning mathematics to solve problems in everyday life using mathematics is the ability of mathematical modeling (Apriliana et al., 2021). The ability defined by Maaß (2006), refers to an individual's skill to perform or complete a task or activity well. In general, ability involves the application of knowledge, skills, and competencies that individuals have to achieve the expected results. Therefore, the ability to create mathematical models when solving problems in daily life can help to interpret daily life events in an easy-to-understand way, which in the process requires mathematical modeling skills. Lestari & Raya (2019) indicate that students' inability to understand the questions asked in word problems and what is known are two of the reasons they are unable to work on them. It is more likely that student’s inability to understand the problem is the reason for their inability to come up with a solution than that they are having difficulties following the processes involved in solving a word problem. Based on the results of the study, it can be concluded that students have a reasonable level of proficiency in translating word problems into mathematical models, as evidenced by the 65.67% of students who passed the word problem solving test. In order for students to answer the given problems while modeling contextual difficulties, they must comprehend mathematical problems in order to model in mathematical terms. Based on the sources reviewed, it can be concluded that mathematical modeling is the process of using mathematics to describe everyday life situations in mathematical form, determine relevant mathematical variables and concepts, build appropriate mathematical models (for example in the form of terms, equations, images, diagrams, functions) to represent everyday life problems, apply mathematical strategies and knowledge to solve the problems, then refer the answer results obtained from solving with mathematical models to the real situation.

Greefrath & Vorhölter (2016) explain the meaning of modeling as a whole modeling process that starts from real world problem, this is subsequently addressed by applying a mathematical model to explain it. This leads to the requirement for the ability to effectively translate real-world situations into mathematical problems so that the problems can be accurately represented through mathematical modeling. (Khusna & Ulfah, 2021). Greefrath & Vorhölter (2016) formulated mathematical modeling indicators as shown in Table 1 below.

Table 1. Indicator of Mathematical Modeling

Indicator	Description
Understanding	constructing a mental model for a given problem situation and thus understanding the question
Simplifying	separating important and unimportant information about a real situation
Mathematizing	translating suitably simplified real situations into mathematical models (e.g. term, equation, figure, diagram, function)
Working Mathematically	applying heuristic strategies and mathematical knowledge to solve the mathematical problem
Interpreting	referring the results obtained in the model to the real situation and thus achieve the real results
Validating	checking the real results in the situation model for adequacy
Exposing	referring the answers found in the situation model to the real situation and thus answer the question

Research on mathematical modeling in learning inside and outside school is starting to be widely developed in Indonesia. Several researchers are interested in developing learning activities or teaching materials to improve this ability (Nuryadi et al, 2018; Zulkarnaen, 2018; Khusna & Ulfah, 2021; Fajri & Hartono, 2022). Several other researchers are interested in analyzing student errors or student conceptions in mathematical modeling (Bahir & Mampouw, 2022; Zulkarnaen 2020). However, none of these studies have used AKM numeracy questions to analyze or improve students' modeling abilities. In fact, in AKM numeracy, a broad context is very important so that students can recognize the role of mathematics in the real world. This shows that there is a relationship between AKM numeracy questions and students' mathematical modeling abilities. According to Pusmenjar (2020), there are four content domains in AKM Numeracy, namely: numbers, geometry and measurement, algebra, and data and uncertainty. Fajri's (2022) research results show that students' abilities in statistics material are still low. Most students experience difficulty in working on the statistical problems given, so it is recommended that teachers involve contexts in everyday life to familiarize students with applying their statistical problem-solving skills. In AKM, of the 4 domains mentioned previously, the domain related to statistics is data and uncertainty, which is expected to enable students to use measures of concentration (class VIII) and dispersion (class X), such as the mean and variance of data, specifically focuses on understanding how to obtain information and present data as well as understanding the uncertainty of events.

The description indicates how well grade VIII students can solve *Asesmen Kompetensi Minimum* problems using mathematical modeling. Thus, the purpose of this study is to characterize eighth-grade students' mathematical modeling ability in addressing *Asesmen Kompetensi Minimum* problems related to data and uncertainty.

METHOD

The approach taken in this research is a qualitative approach with descriptive research type. Qualitative research is a research process to understand human or social problems by creating a comprehensive and complex picture presented in words, reporting detailed views obtained from sources of information, and conducted in a natural setting (Walidin et al., 2015). The definition of descriptive is to describe the meaning of data or describe the phenomena obtained, by showing the evidence (Abdussamad, 2021). Thus, descriptive qualitative research is a study conducted with the main objective of providing a picture or description of a situation objectively in accordance with actual conditions. The mathematical modeling ability of students in completing *Asesmen Kompetensi Minimum* (AKM) questions is the data described in this study. Data were obtained from the modeling ability of students after solving AKM problems that have been adapted by researchers with the research subject as the source of research is one class of VIII grade students.

The research design that will be conducted includes the following: (1) Problem identification. In this study, the purpose of problem identification is to determine the ability of students for mathematical modeling when solving AKM problems. (2) Selecting the research subject: Using purposive sampling, the researcher selected one class of VIII A students, about 26 students, from SMP Negeri 22 Surabaya to participate as the study's subject. Purposive sampling is defined by Abdussamad (2021) as data source sampling with specific concerns. The subject of this study was chosen after taking into consideration the time, location, and state of the class and students. (3) Developing research instruments: Test sheets with modified AKM numeracy questions are the instruments required for this study. The researcher was in charge of preparing this instrument. In addition to developing the instrument sheet, the supervisor was consulted regarding the instrument. (4) Giving the AKM problem test sheet: To determine the students' mathematical modeling proficiency when solving the problem, the students who had been chosen were given the modified numeracy AKM problem test sheet.

A test technique was carried out to gather data, which involved providing a test sheet containing mathematical modeling problems from the modified AKM. After that, students need to do the provided test sheet. Additionally, the answers from the students' answer sheets can be used to interpret the data and describe their ability with mathematical modeling.

Data condensation, data presentation, and conclusion drawing and verification are the three categories of operations that create up data analysis, according to Miles, Huberman, and Saldaña (2014). (1) The process of choosing, minimizing down as well, simplifying, abstracting, and manipulating data to highlight the key points in order to present a more coherent representation to facilitate additional information collecting and availability for researchers is known as data condensation. Here, data condensation is done according to the mathematical modeling ability indicators that were selected. The approach that was used, which involved looking at the answers that students had submitted, and then analyzing the data with a particular focus on indicators of mathematical modeling ability for every problem—each of which included the AKM topic domain—was applied. (2) Data presentation, which involves gathering a collection of data and organizing it into an overview that briefly discusses each modeling ability indication. Data is displayed as graphs based on each student's work and the percentage of students that meet specific indicators, as well as the abilities of mathematical modeling that is evident. (3) Drawing and verifying conclusions: In qualitative research, conclusions are established in response to initial formulations of problems, validated by data collected, presented during the data presentation stage, and determined by data analysis results. A percentage of the total number of students who meet particular indicators of mathematical modeling will be utilized for presenting the conclusions. The following generic formula can be used to find the percentage of students who meet the required levels of mathematical modeling indicators:

$$Percent\ 100\% = \frac{Number\ of\ subjects\ who\ achieved\ a\ certain\ indicator}{Total\ number\ of\ research\ subjects} \times 100\% \qquad (1)$$

The purpose of this data discussion is to provide a detailed description of the number of students who satisfy each indicator of mathematical modeling abilities when solving AKM problems. After that, a qualitative description will be given for each mathematical modeling indicator that the students have achieved.

RESULT AND DISCUSSION

According to the 2018 PISA assessment results, Indonesian students have poor reading and numeracy skills. Based to the Program for International Student Assessment (PISA) survey results, Indonesia's literacy and numeracy scores place it 72nd out of 77 nations. In terms of literacy, 72 out of 77 nations and in terms of numeracy, 72 out of 78 countries (OECD, 2019). These impacts learning since it requires problem-solving abilities, such as modeling abilities when solving a particular situation. In accordance with Novianti's (2020) statement that students' mathematical problem-solving abilities are necessary for resolving issues pertaining to daily life and that they should be able to communicate, think critically and creatively, and collaborate effectively with others. Thus, in order to solve context-based AKM problems, students' reading and numeracy skills are required. These skills are necessary to enable them to decide what actions need to be taken.

The data and uncertainty content domain assesses' students' understanding in obtaining information from the data presented, how to present and process data. In grade VIII, the assessment of understanding focuses on obtaining information from the form of data presentation in tables, bar charts and pie charts, and processing data using measures of concentration using the average, median and mode. The context used is a personal context with reading information about a bakery outlet. The data is presented in the form of a bar chart for the number of sales of 8 outlets in a day and data in tabular form for the production price and selling price of each outlet. Considering the problem already contains the information needed to solve it, context reading besides the call of assignment is not necessary. The type of the problem is matching, which measures the ability of students to match statements with the right answers. The number of answer options is more than the number of question items and there is an exception answer option, so if students are not careful in doing calculations and misunderstand the question, then students choose the wrong answer for the given statement. Figure 1 is a data and uncertainty content domain question.

Based on the diagram above, pair each of the following statements and answers to make them correct!

1.	Sum of the median production price and selling price •
2.	Median of the number of sales in a day •
3.	Mode difference between production price and selling price •
4.	Mr. Andi's average profit from outlets which sales more than the median number of sales in a day •
5.	Average sales in a day •

•	Rp 638.000
•	172
•	Rp 13.000
•	152
•	179
•	Rp 2.500
•	Rp 622.667
•	155
•	142

Figure 1. Data and Uncertainty Content Domain Questions

The graph in Figure 2 provides an overview of the outcomes of students' mathematical modeling skills from questions related to the data and uncertainty content domains.

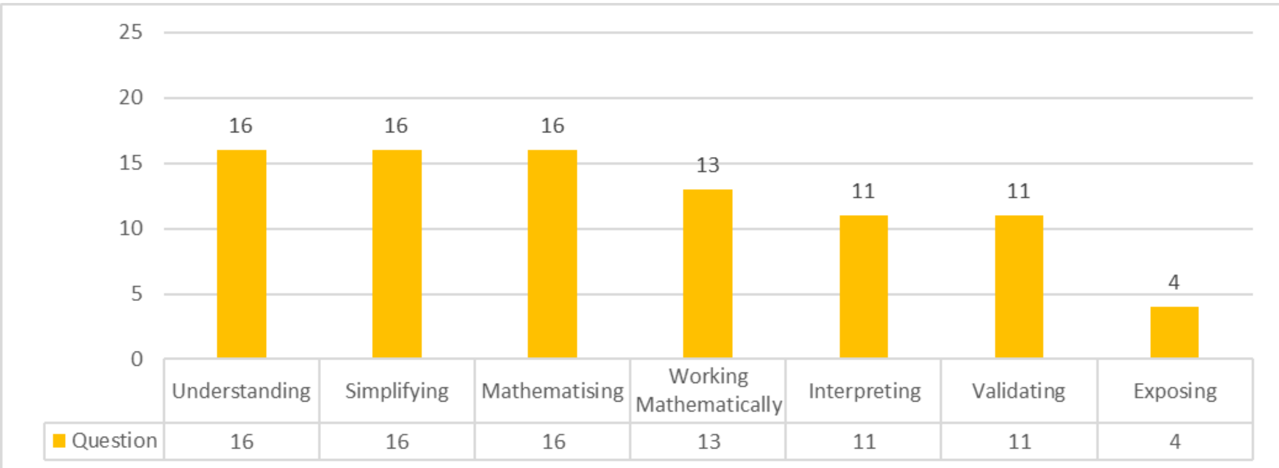

Figure 2. Results of Students' Mathematical Modeling Ability from the Data and Uncertainty Content Domain

The results of students' answers, many students did not write the calculation of the statement that should be answered. Some students' mistakes are in one of the statement calculations, so that students do not answer all questions correctly. There were 15% of students who reached the exposing phase with the correct answer. Some students only reached the validate phase because there was one wrong calculation or formula used, referred to in Figure 3.

In the understanding phase, students understood to use basic statistical concepts, namely the mean, median and mode of single data. Simplifying phase, students know the appropriate formula by using the information in the required diagrams and/or tables listed in the problem. Mathematising phase, students use the formulas of the measure of concentration to answer the question. Working mathematically phase, students should perform calculations with the required formulas and information. Interpreting phase, students refer to the results obtained so that the answer is obtained. Some students only write down how to calculate but do not continue until they get the answer. Validating phase, students check and validate the results of the answers from the models made with the actual situation in the problem.

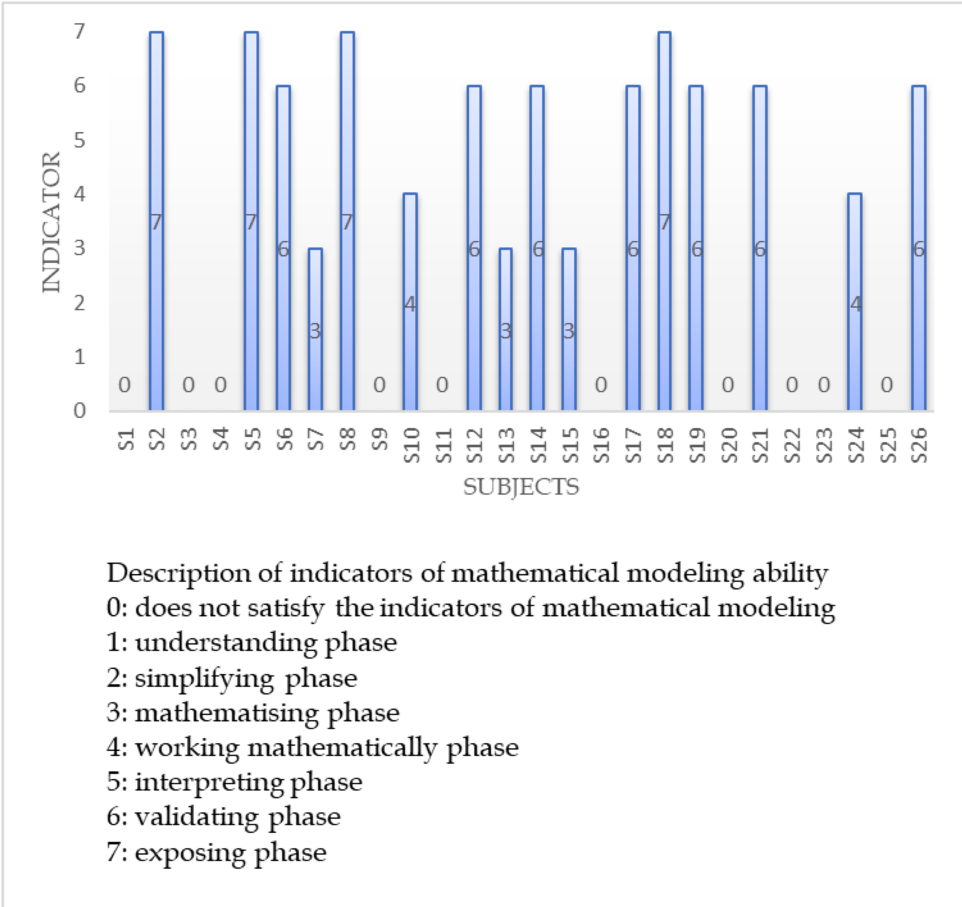

Figure 2. Results of Students' Answers on Data and Uncertainty Content Domain Questions

As seen from Figure 3, of the 26 students who took the mathematical modeling ability test, 10 students or 38% did not answer the question at all and did not meet the indicators of mathematical modeling.

Understanding Phase

Students understand how to solve problems using basic statistical concepts, read data presented in the form of tables and bar charts, and determine and use the average, median and mode formulas. Based on the results of the answers as many as 62% of students meet the indicators of understanding.

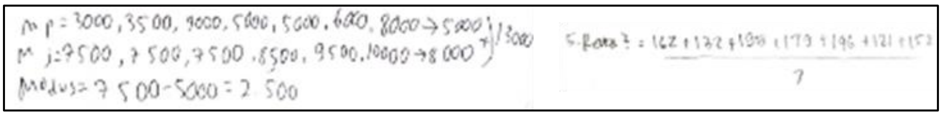

Figure 4. Students' Answers to the Understanding Phase

Students reach the stage of understanding mathematical modeling, because they are able to make calculations using the basic statistical concepts of centering measures for the average, median and mode. The data taken from the bar chart and table presented in the problem, so that students must be able to read and understand the given diagram. Students understand how to calculate the average by adding up all the data then dividing by the amount of data. Furthermore, to find the median or middle value, students must sort from the smallest to the largest data then get the middle value. Similarly, with mode, students understand that mode is the data that has the most frequency. In the data and uncertainty content domain, 38% of the students were unable to understand the question that used the centering measure idea. This is according to the results of studies by Cahyanovianty & Wahidin (2021) that students are more likely to comprehend content-based components like algebra, measurement, and other subjects because they can be completed more quickly than reasoning-based questions and encounter problems when completing the filled with data section of the problem because they take some time and can be a little confusing.

Simplifying Phase

Students separate the necessary information about the given situation. In the simplifying phase, students can write information by reading the data in the table and or bar chart on the answer sheet. Based on the results of the answers as many as 62% of students fulfill the simplifying phase.

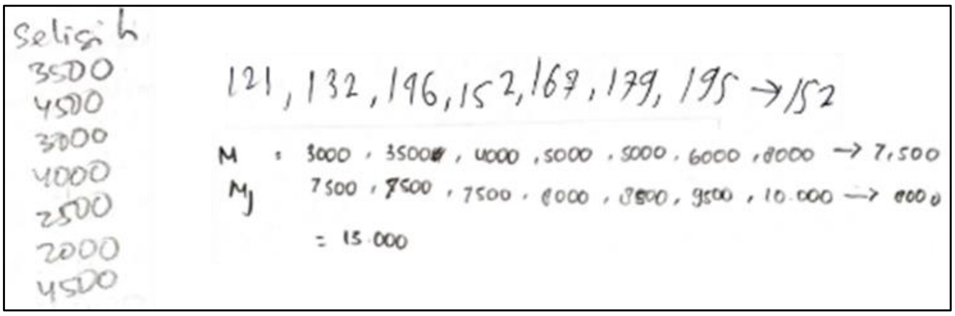

Figure 5. Student's Answer to the Simplifying Phase

Due to their ability to extract the data required to solve the problem and provide an answer, students are able to proceed to the level of mathematical modeling simplification. Students know how to work on the problem by using the appropriate formula and information obtained from the diagram and or table needed.

Mathematising Phase

Students convert the simplified real-world problem into a mathematical model. Students create mathematical models and memorizing during the mathematizing phase. Students use the average, median and mode formulas. As many as 62% of students meet the mathematising phase.

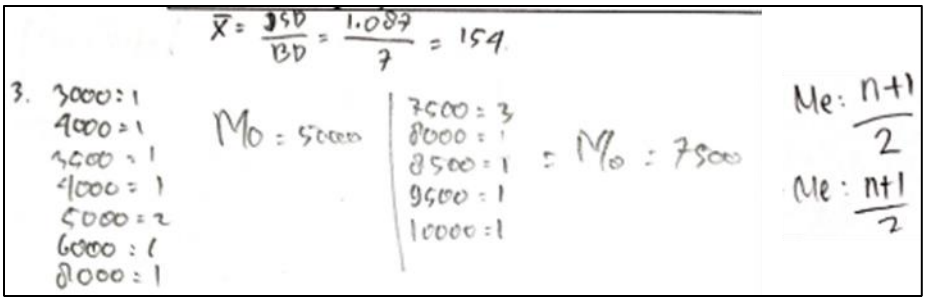

Figure 6. Student's Answer to the Mathematising Phase

Students reach the mathematical stage of mathematical modeling, because students are able to make mathematical models by writing memorization in the form of terms or abbreviations that can facilitate calculation. Students can write the symbol $\bar{x}$ for average, Me for median and Mo for mode. Students have to examine and understand the information given in order to use the average centering measure formula, the median, the mode, and their solution concepts in the data and uncertainty content domain. Khusna & Ulfah (2021) state that if in the process of creating mathematical modeling, the mathematical modeling is not in line with the situation at hand, then the decision or conclusions that are formed will be inaccurate.

Working Mathematically Phase

Students apply the formulas they have learned—the average, median, and mode—to solve their own mathematical model. Some students calculate according to the formula that has been made, but there is a statement about how to calculate which is still wrong. Based on the results of the answers, 50% of students fulfill the indicators of working mathematically.

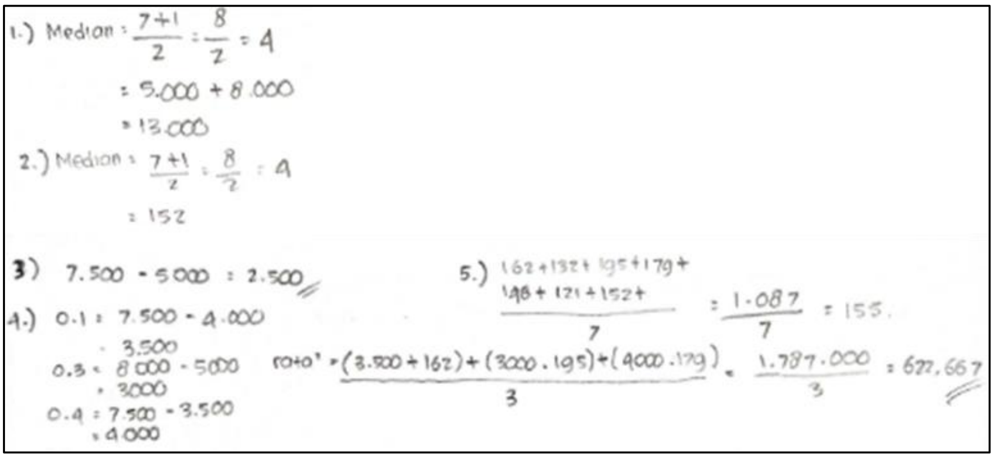

Figure 7. Student's Answer to the Working Mathematically Phase

Through their ability to make calculations, students are able to advance to the phase of working mathematically according to the statement in the question using the average formula, how to find the median and mode. Students process data for the value that must be substituted in the average formula obtained from the bar chart and table in the problem.

Interpreting Phase

After completing calculations on indicators of mathematical work, students receive their solutions. The average, median, and mode formulae' mathematical computations

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correspond to the responses provided by the students. Up to 42% of students successfully complete the interpretation phase.

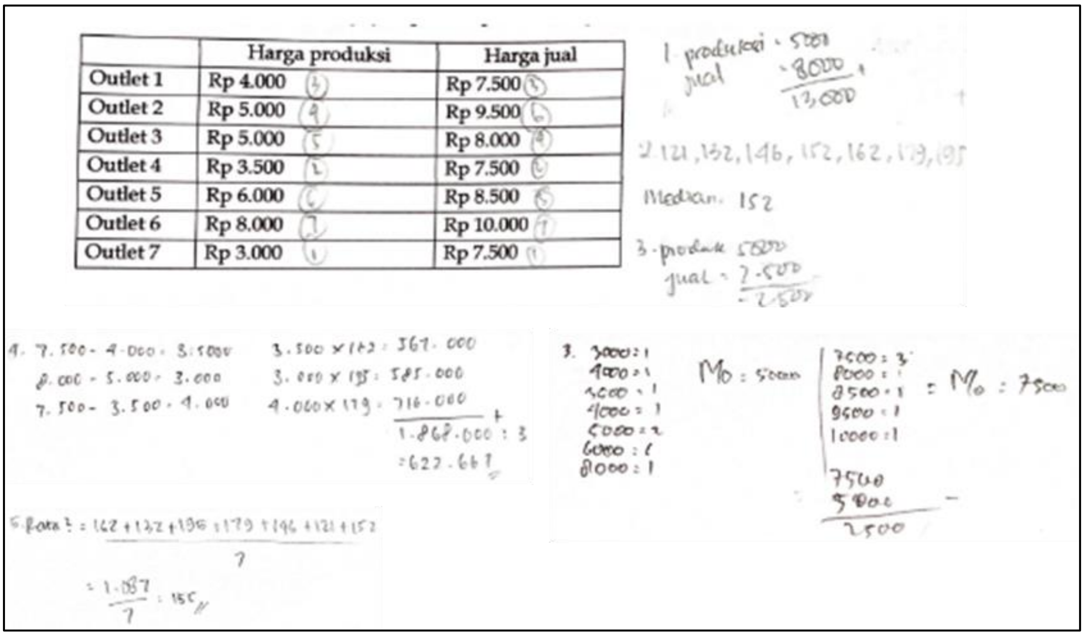

Figure 8. Student's Answer to the Interpreting Phase

Students reach the interpreting stage, because students are able to get the appropriate answer results in each statement after calculating mathematically.

Validating Phase

Students verify and cross-check their solutions by comparing the ones they got from the mathematical model to the real-world scenario in the problem. Students check and then compare the problem-specific response with the answer table provided in the problem. Up to 42% of students satisfy the standards required for validating.

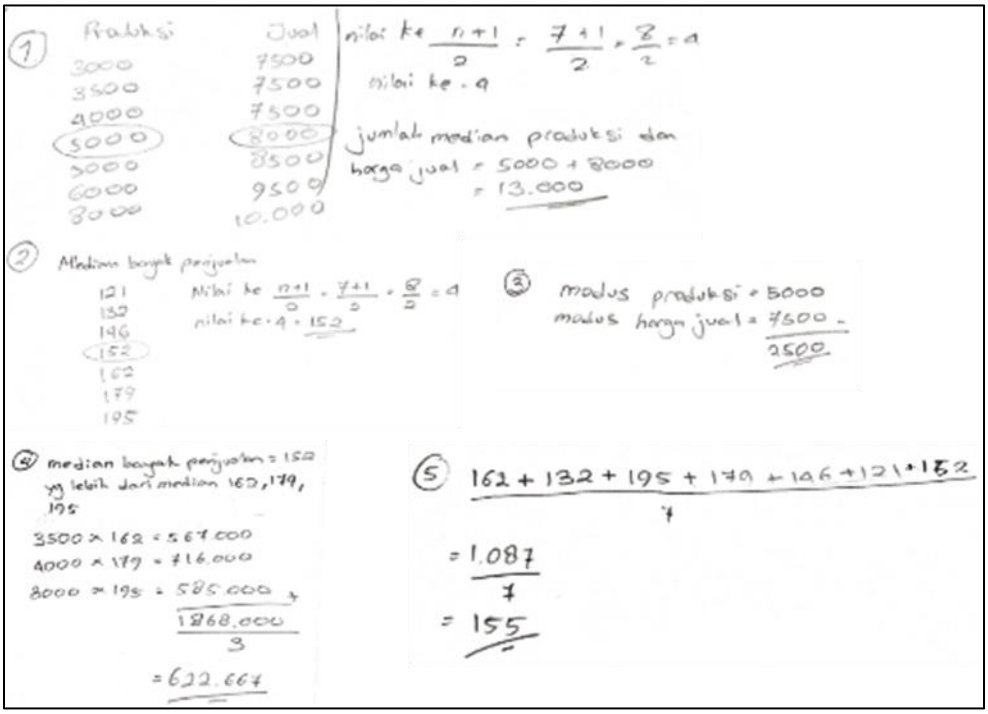

Figure 9. Student's Answer to the Validating Phase

Because they can verify the outcomes of calculations made in the mathematical model into the problem situation provided in the problem, students are able to proceed to the validating phase of the process. After students calculate the average, find the median and mode, students must answer the statement in the problem given by using mathematical operations to calculate the amount or difference.

Exposing Phase

Students accurately respond to the questions in the problem after validating and comparing the answers they got from the mathematical model to the actual situation. Students match the provided problem with the correct solution in matching questions. Fifteen percent of students complete the exposing phase.

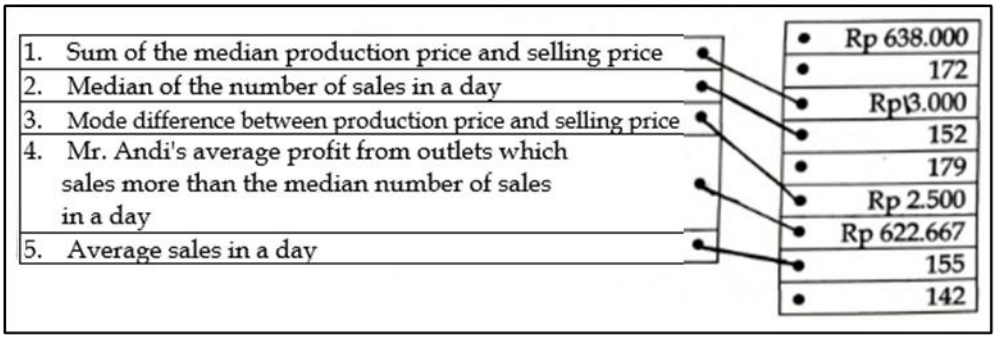

Figure 10. Student's Answer to the Exposing Phase

The students get to the point where they are exposed to mathematical modeling when they can accurately respond to a question by using the answers that have been computed using mathematical modeling and applied back to the given real-world scenario. The type of the problem is matching, so that students must find the right answer and match the statement with the answer obtained. In the form of matching questions, the answer options are more than the statement and there is an exception answer, so that if students are not careful in doing calculations and are wrong in understanding the problem, students choose the wrong answer and do not fulfill the indicator of exposing.

Within the the data and uncertainty content domain, students matched the problem's questions to the available option answers. Because there are more answer alternatives than there are statements, students who are careless in their calculations will select the wrong option. This is in line with studies by Sujadi et al. (2023), which determined that students' knowledge of data content and uncertainty classification is still classified as moderate. Students can only use basic mathematical formulas to solve issues when the provided information and instructions are clear. Confusion develops when students encounter problems that do not directly provide the necessary data or instructions.

CONCLUSION AND SUGGESTIONS

The following conclusions can be drawn from the research's findings: junior high school students in grade VIII have a varied range of mathematical modeling ability when it comes to answering AKM questions in the data and uncertainty content domain. Mostly, students achieve the mathematising phase, where students are able to translate the daily life situation contained in the problem into a mathematical model using the terms average, median and mode. Some students have difficulty performing calculations in one of the methods or formulas, so that students are unable to interpret and validate the answers obtained from the results of the mathematical model into the problem situation given in the problem. Thus, students cannot answer the questions given in the AKM questions in the data and uncertainty content domain appropriately.

The researcher recommends that students be encouraged to arrange their answers systematically, in line with the conclusions that have been presented. This recommendation is based on the results of the research. Teachers might use the method of having students arrange their responses according to previously learned material, questions asked, and responses provided. As a result, students will be used to finishing assignments in an understandable and organized way.

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