Analysis of mathematical modelling ability of line equations of junior high school students

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Abstract. The ability of mathematical modelling is a process of thinking and a process in describing a relationship between mathematics and real-world problems. It is considered to be more easily understood by pouring in the form of models or images. Mathematical modelling acts as a bridge connecting real problems with formal mathematics, it is important because it simplifies and clarifies in understanding the concept of mathematics. One of the algebraic concepts taken in this research is the concept of line equation, where to understand the concept required a mathematical modelling process. The objective of this research is to describe the mathematical modelling ability of eight grade students for the line equation. The research methodology used is qualitative descriptive, with the subject of research is eight grade students of Junior High School. The instrument of the research is questions of mathematical modelling and interviews with students. The conclusions of this study indicate that junior high school students in general still have difficulty in doing mathematical modelling, especially on the line equation. Based on the results of this study, the writer made as a preliminary study for further research on Dissertation to select appropriate models and teaching materials to improve students’ mathematical modelling.

1. Introduction

One of the important mathematical skills that need to be mastered by students is the ability of mathematical modelling. It is in line with the opinions expressed by Blum and Ferri [1] which states that having a mathematical modelling ability will help students to better understand the world; supporting the learning of mathematics (motivation, concept formation, understanding and reasoning); contribute to developing a range of mathematical competencies and appropriate attitudes; as well as contributing in providing an overview of mathematics. Based on the statement from Blum and Ferri [1], it can be said that by understanding mathematical modelling, mathematics will become meaningful for the learners. Similarly, the opinion expressed by Kaur and Dindyal [2], she explains that mathematical modelling plays an important role in the development of mapping and mathematical understanding where students are required to be able to create formulas and develop mathematical models to represent and solve mathematical problems as well as problems in everyday life.
Cheng [3] in his research found that, mathematical modelling provides an opportunity for learners to be able to identify problems that ultimately arrive at finding a solution, rather than merely memorizing the formula given by the teacher. The importance of mastering mathematical modelling is also in line with NCTM [4] which highlights the students' understanding of understanding the relationship between mathematical ideas and applying them outside the mathematical world within the scope of mathematical ability and emphasizing mathematical applications and mathematical modelling processes. Furthermore, in the curriculum that has been applied in Indonesia contains competencies that must be mastered by students include: problem solving that include the ability to understand problems, design mathematical models, solve models and make a solution; communicate ideas with symbols, tables, graphs or diagrams to clarify circumstances or problems Depdiknas [5]. These competencies aim to develop and emphasize the importance of ways systematically thinking that generates solutions to real-life problems through modelling.

English [6] suggested that students succeed applying modelling in his life, then mathematical modelling abilities must begin to be introduced to students from the early years of primary school through high school. In line with the results of research from Arseven [7], finds the fact that the importance of mathematical modelling is applicable to the teaching of elementary, high school and high school mathematics, it is considered that ability of mathematical modelling will contribute to the development of learning mathematics education. OECD [8] explains that mathematical modelling abilities have become the foundation in PISA 2015 and have been incorporated into worldwide curriculum systems. In line with Anhalt & Cortez [9] explain that the ability of mathematical modelling has become an essential component of the secondary school curriculum, where students experienced to use mathematics in the interpretation of physical phenomena, social or scientific phenomena or it can be said that mathematical modelling can be used to clarify and interpret phenomena with the aim to solve the problem.

Warwick [10] explains that mathematical modelling is not merely capable of applying mathematics, but about learning mathematics as a whole both about concepts and skills and applying mathematics in everyday life. Gravemeijer [11] also explains that the model acts as a bridge connecting real and formal mathematical problems. Cheng [12] explains that mathematical modelling is a process of representing real-world problems, the term in its math is the attempt to find solutions to a mathematical problem. Mathematical modelling can be regarded as a simplification or abstraction of real-world problems or situations into mathematical forms. According to Verschaffel, et all [13], mathematical modelling is the process by which real-life situations and relationships in this situation are expressed by using mathematics. Both perspectives were emphasized beyond the physical characteristics of a real-life situation to examine the features through mathematics. Haines & Crouch [14] characterizes mathematical modelling as a cyclical process in which real-life problems are translated into mathematical languages, solved in a symbolic system, and the solutions are re-tested in real-life systems. Cheng [3] explains that mathematical modelling process starts from the problem-oriented practical mathematical modelling in the real world, the problem is formulated into a mathematical problem. Mathematical problems are analyzed and solved using known mathematical methods, mathematical solutions are then interpreted into some real-world solutions that make sense. Validation of mathematical models requires checking the accuracy of a mathematical solution or relating it to the observed data or comparing it with other models. Reasoning in mathematical modelling will determine whether the process needs to be repeated.

Based on some opinions above, it can be seen that there are two roles of mathematical modelling. The first role as revealed by Cheng [12] & Cheng [3] that role of mathematical modelling is as a tool to solve the problem, and the second role according to Gravemeijer [11] “mathematical modelling acts as a bridge to connect contextual problems with mathematical concepts”. Mathematical modelling acts as a bridge connecting real problems with formal mathematics, it is important because it simplifies and clarifies the nature of understanding mathematical concepts.
One of the algebraic concepts taken in this research is the concept of line equation, where to understand the concept required a mathematical modelling process. Tanjungsari, et all [15] explain that the nature of his research is to diagnose the difficulties of learning mathematics in junior high school students about line equations include: (1) difficulties in the ability to translate (linguistic knowledge) is indicated by errors in the interpretation of language; (2) difficulties in using the principle, indicated that students do not understand the variables, lack of mastery of algebra and lack of schematic knowledge indicated by number operation errors; (3) difficulty in using concepts, demonstrated by inability to remember concepts, inability to deduce concept information and lack of schematic knowledge indicated by incomplete writing of formulas and: (4) difficulties in algorithmic abilities, including lack of planning ability (strategy knowledge) and in the ability of solving (algorithmic knowledge) is shown by not doing the problem, not finished and lack of accuracy to do.

Based on the difficulties encountered by Tanjungsari, et all [15], the authors pointed out that the difficulties are caused by the students have not understood the given situation so that the student has not been able to translate the information provided to solve the problem. The author analyses that when the students are able to translate the information provided then the students will be able to create a model that then analyses it and is able to perform operations on the model so that students can solve the problem. Therefore, the authors see the very importance of students mastering the ability of mathematical modelling, especially to solve problems related to the equations of line equations that the application we often encounter also in our daily lives. Based on the explanation above, this research is aimed to describe the extent of mathematical modelling ability of junior high school students in line equation.

2. Literature Study
Cheng [12] defines mathematical modelling as a process of representation of the real world in the form of mathematics as an attempt to find solutions to problems. Cheng describes the mathematical modelling as the diagram below:

![Mathematical Modelling Diagram](image)

**Figure 1. Mathematical Modelling (Cheng)**

According Carrejo and Marshall [16] Mathematical modelling is a representation of the real world through the construction of mathematics both in concept and tool. In line with Blum & Leiß [17], mathematical modelling as a real problem-solving process that passes through stages: simplifying real problems into a real model, then from a real model transformed into a mathematical model can be a diagram, graph, table, equation or mathematical expression, then from a mathematical model solved by mathematical means to obtain mathematical solutions, and from mathematical solutions interpreted in the solution of the original real problem. Thus, it can be simplified to: (1) simplify the problem; (2) create a mathematical model; (3) complete the mathematical model; (4) interpretation; (5) validation.
Arseven [7] defines mathematical modelling as transforming problem situations into mathematical models. But this concept began to be used often to define the process including all the steps of mathematical structuring, mathematical work and interpretation/verification. Sometimes the given problem situation is none other than a pre-structured mathematical problem or a full-blown mathematical problem with real life. Blum and Leiß [17] shows the modelling process cycle in the 7 steps given below to aid the cognitive analysis of modelling situations, mathematical expressions of a problem and problem-solving process: Understanding the situation (problem); Simplifying/ structuring; Mathematizing; Mathematical working; Interpretation; Verification; Presentation. In line with Blum and Leiß [17] in 2015, Anhalt and Cortez [9] shows the modelling process cycle in 7 steps as follows: Analyzing problems; Develop and formulate a model; Modelling; Interpretation; Validation; Develop and formulate new models; Report a settlement. In this study, the author took to seven cycles according to Anhalt& Cortez [9] as an indicator for measuring the ability of mathematical modelling.

3. Research methods

This research is a qualitative descriptive research, where this research is focused on analysing the extent of mathematical modelling ability of SMP students on line equation. The sample in this research is eight grade students of junior high school in one SMP Bandung in the academic year 2017/2018, it consists of 20 students. The research instruments include mathematical modelling test and interview guidance.

Indicator of mathematical modelling ability consists of: analysing problem; developing and formulating a model of; modelling; interpretation; validation; developing and formulating a new model; and reporting settlement. Interview guides are used to obtain information about student answers. Data collection is done by triangulation techniques that compare the result of test and interview.

The data analysis technique consists of assessing student answers based on the mathematical modelling test that has been given, then determining the extent of the students’ understanding of each indicator on the mathematical modelling abilities in accordance with the results of interviews. To know the number of students who are able to answer each indicator of mathematical modelling ability researcher uses the following percentage formula:

\[ P = \frac{n}{N} \times 100\% \]

Information:

\( P = \) Percentage of students who answered
\( n = \) Many students provide answers for each indicator
\( N = \) Number of samples

Ali [18] creates the percentage of the number of students who answer each indicator as follows:

| Percentage (P) | Criteria       |
|----------------|----------------|
| \( P \geq 55\% \) | Very high     |
| \( 40\% \leq P < 55\% \) | High          |
| \( 25\% \leq P < 40\% \) | High enough   |
| \( 10\% \leq P < 25\% \) | Low           |
| \( P < 10\% \) | Very low      |
4. Results and Discussions

Based on analysing the results of student answers in solving the problem of mathematical modelling abilities about straight line equation, the result is not as expected. As explained above that the measurement of mathematical modelling ability includes aspects of analysing problems, formulating a model, modelling, interpretation, validation, formulating new models and reporting on completion. Here is the percentage of overall results from student answers of 20 students in solving the problem of mathematical modelling.

| Aspects to be measured         | The number of students | Percentage | Criteria      |
|-------------------------------|------------------------|------------|---------------|
| Analysing Problems            | 10                     | 50%        | High          |
| Formulating a Model           | 8                      | 40%        | High enough   |
| Creating Models               | 6                      | 30%        | High enough   |
| Interpretation                | 3                      | 15%        | Low           |
| Validation                    | 1                      | 5%         | Very low      |
| Formulating a New Model       | 0                      | 0%         | Very low      |
| Reporting the Settlement       | 0                      | 0%         | Very low      |

Based on Table 2, from 20 students in the class that used as research sample there were 50% of students able to solve the problem analysis aspect, with high criterion. Student who able to formulate a model as much as 40% with high enough criteria, student aspect able to make model there are 30% with high enough criteria. In the aspect of interpretation students still have difficulty, because only 15% who reached that stage. At the validation stage, formulating a new model and reporting the completion earned a very low percentage. Students tend to focus only on the end result, they do not pay much attention to every process through which to solve the problems. Students still tend to memorize and still lack understanding of concepts.

By looking at the results of table 2 it can be said that students still have difficulty in understanding the ability of mathematical modelling. Of the 3 pieces of given questions, students are only able to work on the problem until the model makes the model. Students are still not able to work on the problem for the next stage that is on the indicators of interpretation, validation, formulate a new model and the final stage of completing the completion. Whereas according to Cheng [03] Validation of mathematical models is very important, because it requires checking the accuracy of the mathematical solution or connect it with the observed data or compare it with other models. Reasoning in mathematical modelling will determine whether the process needs to be repeated by examining how the mathematical problem has been formulated.

General description of student work results seen from the process of solving the problem of mathematical modelling ability as follows:

**Problem No. 1**

Mr. Ronny's Building Store will lower the price of assets owned. In the asset reduction process, the life span of asset benefits will be determined and then the asset will shrink the same amount each year until the taxable price of the asset is zero. Mr. Ronny bought a truck for Rp. 450,000,000.00. The price of the truck will decrease Rp. 18,000,000.00 per year. Make assumptions about the above problem! Then specify what information and variables involved in the problem above!

a. Make a depreciation equation based on the problem above!

b. Determine the point of cutting the line with line X and line Y. then draw a graph of the equation you find!

c. Shows whether the line breaks with line X in this issue?

d. Shows whether the line breaks with line Y in this issue?
Here are answers given by students:

![Figure 2. Sample of Student Answers](image)

Students are still mistaken in understanding the problems that exist in the given problem. On the problem students write down the assumption that the decrease is given by variable x and depreciation is variable y. y should be a variable for the price of the car and x is the variable for the age of the truck in a year. Here is a snippet of interviews with grade eight students who gave the results of the answer. Students are coded with S, and the author himself as the interviewer is coded P.

Q: Did you finish number one?
S: Yes, we did
Q: When you're done doing the number one thing, try to explain, the point of the question?
S: I think this is a matter of equations on a line equation.
Q: Besides, what else do you get from the problem?
S: It says Mr. Ronny bought a truck for 450,000,000 and shrunk 18,000,000 per year.
Q: Then what are you doing to answer the question of Part A?
S: I make the decrease as variable x and depreciation as variable y
Q: Are you sure about your answer?
S: Sure
P: You said "it written that Mr Ronny bought a truck for 450,000,000 and shrinking 18,000,000 per year "is this information cannot be used to answer question part A?
S: Emmm…yes it can uh... but it’s confusing.

From the results of answers given by students and based on the results of interviews can be concluded that students are still experiencing confusion when the questions are made associated with daily life. Students are still difficult to understand the situation given to the problem and still confused to answer questions that are not routine.

Question b is the student asked to make the equation of depreciation, the student makes two equations, i.e. the first equation is \( x - y = 450,000,000 \) and the second equation is \( x + y = 18,000,000 \). of the two equations made by the student, it appears that the student does not understand the intent of the question given consequently in formulating a model in the end becomes wrong, the student should make the equation \( y = 450,000,000 - 18,000,000 \) \( x \). Here are the results of interviews with students in answering questions of part b.

Q: Now we go to question part b). Whether you can make the equation?
S: Yes, we can. There are two equations, first $x - y = 450,000,000$ and the second equation $x + y = 18,000,000$.

Q: Why are there two equations?

S: Because there is depreciation Miss.

Q: Is it possible if $x - y = 450,000,000$ but when $x + y = 18,000,000$?

S: Emmm ... yes its possible.

Q: Please check again.

S: I am confused because from the beginning I don’t really understand what the problem is.

Q: After that what did you do?

S: Since there are two equations then I have to determine $x$ and $y$ through elimination process.

P: Then after getting the value of $x$ and $y$ what is the next step?

S: I made a cut point of axis $x$ and axis $y$, then made the graph.

Q: Why should we make a graph?

S: To see the intersection of both axes.

Q: Does looking at the cutting point help you in answering question?

S: Emm ...not sure because it’s actually confusing.

From the mistake in writing the assumption in question a, in the end the student becomes wrong in translating what information is given to become a mathematical problem that can be solved. In the end the mistakes made by students continue to the aspect of interpretation, validation, formulate new models and aspects of report completion. The mistake was made by almost the majority of students in the class, as for students who were able to analyse the problem and only able to make the model only 30%. The average student who is able to solve the problem up to the aspect of formulating the model is the student with high ability in his class.

From the analysis of mathematical modelling test and student interview, the writer analysed that the students still tend to have difficulty in solving the problems related to real life. The mathematical modelling process should be seen as a simple scheme rather than an algorithm that needs to be traversed. Students must be able to understand the situation of the given problem, the situation is made more simple, structured and made more precise. Then the model should be built towards the real situation, turning the actual model into a mathematical model. In the end if the students are able in the final stage is to be able to solve the problem given then the students are able to perform modelling stages.

5. Conclusion

From the results and discussion above it can be concluded that junior high school students in general still have difficulty in doing mathematical modelling, especially on the line equation. The aspect of mathematical modelling capability that is still considered difficult by students is on aspects of modelling, interpretation, validation, formulating new models and aspects of reporting completion. By looking at the conclusions obtained, the authors are interested to conduct further research in order to be able to develop mathematical modelling capabilities for students by selecting models and teaching materials can be appropriate.

Acknowledgments

The researcher is grateful to LPDP who has financed the seminar and also to the teacher and student of one of the junior high school at Bandung, as well as for academic researchers, Prof. Dr. H. Yaya S. Kusumah, M.Sc. Especially thanks to Dr. Heris Hendriana, M. Pd and Dr. Euis Eti Rohaeti, M.Pd. which have given opportunity, so that author could participate as student in Indonesia University of Education. Hopefully the results of this study can provide a preliminary picture for further research that will be conducted by researchers and hopefully provide a positive impact for the world of education.
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