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Male students' visual reasoning in solving mathematical problem

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Abstract. To improve their ability, students must solve math problems. This paper discusses the visual reasoning of the students in solving mathematical problems. Qualitative research methods with task-based interviews was used to collect and analyze data. Saturated data triangulated results were used for analysis. The results of the research showed that male student solves problems are math to Polya theory, identified visual reasoning, the reasoning is done in deductively and inductively, visualizations performed contextually and mathematically. Visual reasoning can help student in solving mathematical problem.

1. Introduction

Mathematics can be viewed as a tool for solving problems. In mathematics learning, teachers are more often given problems for students to be solved. In mathematics learning in general, it can be represented 20% of the material, and 80% of exercise solves the problem. This can be understood because learning mathematics aims to organize reason, form attitudes, and improving mathematical skills [1]. Mathematics grow from mathematics learning.

As a tool for solving problem, learning mathematics can be represented by troubleshooting to solving mathematical problem. Four troubleshooting stages are understanding, planning solutions, implementing plans, and checking back [2]. Students are faced with a problem, not merely solving problems, but also learning something new [3]. Three common problem-solving models in Indonesia in mathematics, which are: writing known or separating, writing what is asked or writing what will be proved, and answering or proving [4].

Mathematics provides many formulas to help students solve problems. In resolving the problem, it is necessary for reasoning and visual thinking. Although with visual thinking, students solve the problems by following the stages of Polya, namely: understand, plan, implement, and looking to back [5, 6]. In solving mathematical problem, there is no denying that there are some flaws in solving the problem for some student [7].

The reasoning is the process of thinking of linking known facts to a conclusion [8]. Reasoning is an activity of logical and analytical thinking in discovering a truth [9]. Human reasoning relies on the construction and manipulation of mental models used as an explanation of knowledge [10]. The



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reasoning features include logical and analytical thinking [11]. The reasoning indicator is presenting a written mathematical statement and drawing, performing a mathematical manipulation, examining the validity of an argument, and drawing conclusions from the statement [12]. Based on the process, reasoning can be differentiated into two namely: deductive reasoning and inductive reasoning.

The student's speed in resolving problems varies. High-proficiency students can solve problems quickly. Students who have low ability tend to be sluggish to solve the problem. Nevertheless, the way of resolving the problem between students of high proficiency with low is the same. A preliminary study shows that there are some problems still found in learning. Most students are still struggling in visual thinking because they are too focused on formalities [13]. Otherwise, the using of mental imagery of students for mathematics material is very lacking [14, 15].

This paper discusses the visual reasoning of male students in solving mathematical problems. In learning, the students were bring a lot of experience, less supple, want to be appreciated, have initiative, and independent [16]. Because of its, it is expected that the visual reasoning process can be obtained. The novelty or this research is we get the profile of visual reasoning of male students in solving mathematical problems.

2. Methods

The research method used, to get visual reasoning of male students in solving mathematical problems, was qualitative research method. The simple flowcard of the method was as follows.

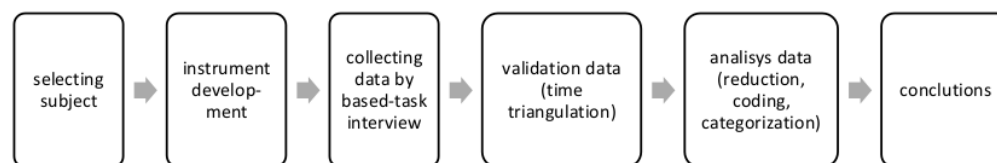


Figure 1. Flowcard of research method

The subject of the research was a student of the Mathematics Education Study Program of Universitas PGRI Madiun. The subject criteria was students of the Mathematics Education Study Program, having moderate ability (which is shown from the test results), and male gender.

The auxiliary instruments used are the task sheets that have been analyzed. Instrument analysis was done to ensure in obtaining data. Additionally, the task sheet was validated by some experts. The problems that used on the task sheet was as follows.

A company has one car of Mitsubishi, one car of Suzuki, and car of Daihatsu that used to distribute three types of food, namely: rice, noodles, and cooking oil. Mitsubishi vehicle is capable of carrying 19 sacks of rice, 10 cardboard noodles and 24 packs of cooking oil, Suzuki car capable of carrying 6 sacks of rice, 4 cardboard noodles and 8 packs of cooking oil, and Daihatsu car is capable of carrying 11 sacks of rice, 6 cardboard noodles and 14 pack of cooking oil. How many times the transport of each car of Mitsubishi, Suzuki, and Daihatsu if the company distributes 100 sack of rice, 56 cardboard noodles, and 128 packs of cooking oil?

Some subjects were taken for instrument trials. The results of the analysis and test of the instrument showed that the problem given can give profile of visual reasoning in solving the mathematics problem.

According to the agreement between the researcher and the subject of research, the interview was conducted on Thursday, 5 January 2017. There are 27 student to be the respondent as the subject research. In this interview used a task sheet solving math problems. The in-depth interviews with semi-structured formatting are used to obtain data that is natural and profound. Just 1 communicative student was to be subject research in-depth interviews.

Once data is obtained, data exposure, data reduction, coding, and triangulation are performed. At first, information is displayed as it is to show the nature of the data. After that, data reduction is made that eliminates information that has no relation to visual reasoning of students. Besides, coding is also done to make it easier to search data. After that, the data is being triangulation that is compared so that it obtained valid data. Triangulation time is used to clothe the data that used is saturated data.

Visual reasoning of male students in resolving mathematical problems obtained based on the results of categorization of valid data. The student stages in solving problems was using Polya theory. Student reasoning was reviewed based on deductive reasoning and inductive reasoning. The visual reasoning gained was based on the results of in-depth interviews and field notes.

3. Result and Discussion

Analisis data give the result of the research. Not all subject activities are identified to perform visual reasoning. To solve the problem, the male subject performs understanding, planning, implementing, and checking back as follows.

3.1. Understanding with contextual visualizations and plan to finish with math

The first step that subject take to solve problem is understanding the question by visualizing and contextually. To understand the problem, the subject explains and imagines that

"... Mitsubishi car is capable of carrying 19 sacks of rice, 10 cardboard noodles and 24 pack of cooking oil, Suzuki car capable of carrying 6 sacks of rice, 4 cardboard noodles and 8 packs of cooking oil, and Daihatsu car capable of carrying 11 sacks of rice, 6 cardboard noodles and 14 packs of cooking oil. Continue, how many cars were transporting if the company wanted/distribute 100 sack of rice, 56 cardboard noodles and 128 pack of cooking oil?"

Further interview results, the subject explained that in understanding was crossed shadow, cars, rice, cardboard, and so on. Then, the subject plan to solve the problem with mathematics. The subject says *"...say that the car was x, the Suzuki car was y and the Daihatsu car was z. So, we can write from the issue $19x + 6y + 11z = 100$, $10x + 4y + 6z = 56$, and $24x + 8y + 14z = 128$... Because if we use the words are too long... to get a solution"*.

The data pointed out that in this activity, the subject has performed inductive reasoning by using mental imagery contextually. The data pointed out that the subject's activity has done reasoning inductively. The subject takes conclusions to solve the problem with mathematics. Conclusions are decided based on previous learning experiences to resolve the problem given by lecturers or teachers with mathematics. Thus, the reasoning used is inductive.

3.2. Planning, executing and checking with elimination/substitution

After getting the mathematical model of the given problem, the subject plans to solve the problem with the elimination/substitution. The representation of this activity is numbering. When planning to resolve the problem with the elimination/substitution, the subject explains that *"to distribute the goods, then the value must be positive, so we use a condition: that where x, y, and z. It should be more than or same with zero"* while writing. The subject says that *"...to remove the x, y, and z variables. This is an easy way..."* and *"... Because usually if there is such a problem, the easiest way to do elimination and substitution"*. Furthermore, the subject executes his plan to solve the problem with elimination/substitution. The subject says, *"...because usually if there is such a problem, the easiest way to do is elimination and substitution, but after the elimination of the result is eliminated zero.... Equation 4 and 5 and eliminated the elimination again, because of the result of this zero, can not"*. However, the subject continues by giving the value $x = 0$, $z = 0$ so it is obtained $y = 2$ and the value z

= 8, x = 4 so it is obtained y = 4 to examine and convince the self. Activities to planning, executing, and checking with elimination/substitution can be represented as follows.

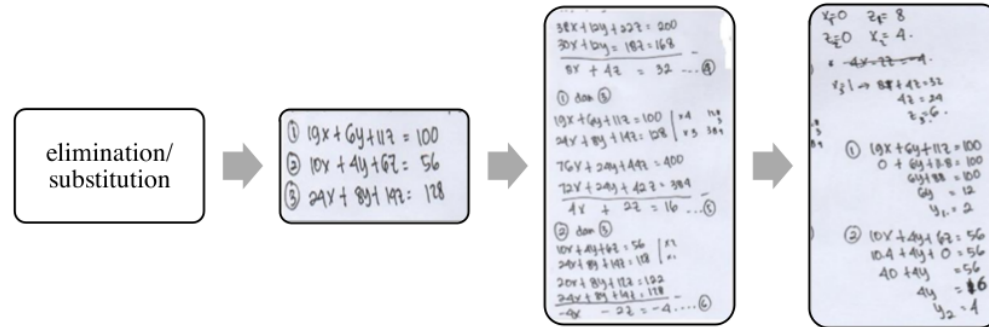


Figure 2. Planning, executing and checking with elimination/substitution

The data shows that in this activity, the subject has done reasoning inductively and deductively. When planning to solve problems by elimination/substitution, the subject reasoned inductively by assuming that all mathematical problems can be solved by elimination/substitution. When carrying out, the subject reasoned deductively, that is in accordance with his plan to solve using elimination/substitution. When checking back, the subject reasoned deductively so that he concluded that what was done was not biased to answer or complete the falsification. This is done by matching the results of his work with the problems given.

For this activity, the subject does not involve mental imagery. Whether for planning, executing, or checking, the subject does not use images or mental imagery. The subject only resolves procedurally using elimination/substitution. Thus, the reasoning used by the subject is without visualization.

3.3. *Planning, executing and checking with matrix*

After trying to solve the problem by elimination/substitution, but the problem can not be solved, the subject resolves the problem with the matrix. The subject have planing to solve the problem with matrix. The subject claims "... It's (elimination and substitution) the way... but the result is zero value, they can be used another way that is determination... Because it's easier and if using determinant is somewhat difficult". The subject says "... because of this is an easy way... use matrix, the determinant of the matrix". The subject says "... Use matrix, the determinant of the matrix. The result of completion is zero, can't." Activities approved, implemented, and approved planning, executing, and checking with the matrix can be represented as follows.



Figure 3. Planning, executing and checking with matrix

The data pointed out that the subject's activity has done reasoning inductively and deductively. When planning to solve problems with a matrix, the subject reasoned inductively by saying that if a problem cannot be solved by elimination/substitution it will be solved using a matrix. When carrying out, the subject reasoned inductively according to plan. When checking back, the subject reasoned deductively by comparing the results of his work with the problem given. Because the determination is zero, it is concluded that the problem cannot be solved.

The subject does not think visually when overcoming problems with the matrix. Data shows that in this activity, the subject did not visualize. Subjects only perform procedural to use a matrix in solving the given problem. No subject activity was identified using visualization.

3.4. Planning, executing and checking with coordinate points

After trying to solve the problem with the Matrix, but the subject feels dissatisfied and concludes the need for other plans, the subject plans to resolve the problem with the coordinate point. The reasoned subject is "... because in the earlier way, was not able to finish.... those ways were not found the result (can not)". Furthermore, the subject said, "...next to the point of the coordinate that is to correct or substituted if x equals zero then found y value of what is and z met how many". The subject explains "... This way is easier, by the way that the coordinate point can be immediately found its completion". The subject checks again by resubmitting the numbers of equations 1, 2 and 3. The subject describes "x, y and z variables associated with the number of car transports and after being closed, the result is appropriate... Same. The result is the same.". Activities approved, implemented, and approved planning, executing, and checking with coordinate points can be represented as follows.

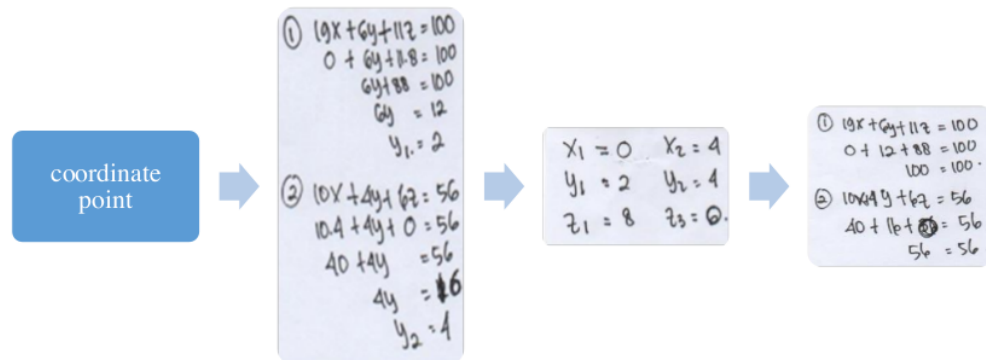


Figure 4. Planning, executing and checking with coordinate points

Finally, the subject argues, "... if the problem after being transformed into a linear equation form with the variable like this, yes, the completion of the substitution or elimination, can use the matrix, and continues by coordinate point."

Based on the analysis of the data, it shows that in this activity, the subject has done reasoning inductively and deductively. When planning to use a coordinate point, the subject reasoned inductively by assuming that all problems can be solved with a coordinate point. This is also supported by the subject's bad experience that the method of elimination/substitution and the way the matrix fails. When carrying out, the subject reasoned deductively as planned. When checking back, the subject reasoned deductively by comparing the results of the work of implementing the plan with the problems given. Its to be the novelty of this research that in solving mathematical problem, student has done reasoning by inductively and deductively.

Beside visualizing by contextually, the data shows that the subject visualizes by mathematically. Visualization is done by using the coordinates. Coordinate points are points that can be drawn using the coordinate system. The term used by the subject explains that the subject thinks mathematically visual in this activity. Its to be the novelty of this research that in solving mathematical problem, student has done visualizing by contextually and mathematically.

4. Conclusion

To solve the problem of mathematics, male students perform the steps of completing Polya completion, namely: understand the problem with visualization, plan the problem solving mathematically, plan to solve the problems with elimination/substitution, implement the plan to solve problems with elimination/substitution, examine the results, plan to solve the problems with determinations, implement plans to solve the problems with determination, checking results, planning to solve the problems with the coordinate points, implementing a plan to solve the problems with the coordinate point, and check the results of the sponsorship with the coordinate points. Each activity in resolving the problem, the subject has done reasoning. However, not all subject activities are identified to perform visual reasoning. Students tend to still focus on formalities. In solve the problem, the subject performs reasoning by deductively or inductively, and visualizes by contextually and mathematically.

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