How to analyze the students’ mathematization competencies in solving geometrical problems?

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Abstract. Mathematization competency is considered in the field as the focus of the modeling process. This study aims to determine the extent to which the students mathematization competencies in solving geometrical problems. This research uses the descriptive qualitative method by using purposive sampling technique. The data in research are the result of contextual geometry problems and interview by the 8th graders of Junior High School in Surakarta. After that tested to five students can be concluded that students difficulties in horizontal and vertical mathematization. Students difficulties in horizontal mathematization refer to cannot transferring a real-world geometry problem to a mathematical model and difficulties vertical mathematization is adjusting, combining, refining and integrating models.

1. Introduction

Mathematics is one of the lessons that train problem-solving skills as well as the expected objectives of the National Council of Teacher of Mathematics (NCTM) math learning. Five standard mathematical abilities that must be possessed by students, namely problem solving, communication, connection, reasoning, and representation [1]. Solve problems that include the ability to understand problems, design mathematical models, solve models and interpret solutions obtained [2]. Therefore, students need to be trained in transforming realistic problems into mathematical models.

Students in changing the real problem to the form of mathematical modeling and vice versa have difficulties. The interphase between real-world problems and mathematical models that present students' difficulties is to translate realistic problems into the form of mathematical models and instead change the form of mathematical models to realistic problems [3]. The forms of student error in modeling problems include the student's difficulty in creating a relationship between reality and mathematics, and to simplify and structure the reality, as well as problems related to mathematical solutions [4].

The competency used to translate realistic problems into formal mathematical forms is called mathematization competency. Mathematization is the transformation of the real world situation into a mathematical problem through modeling cycle [5]. Mathematization consists of horizontal mathematization and vertical mathematization. Horizontal mathematization as an event of a change of contextual problem becomes a mathematical model, while vertical mathematization is the process of problem formulation into various mathematical solutions by using some appropriate rules [6].

The process of horizontal mathematization includes the following activities: a. Identify mathematical concepts relevant to real-world issues; b. Represents the problem in a variety of different ways, including organizing problems according to relevant mathematical concepts, and formulating appropriate
assumptions; c. Seeking the relationship between language problems with symbols and formal language of mathematics so that real problems can be understood mathematically. d. Seek regularity of relationships and patterns relating to problems; e. Translates the problem into a mathematical form, i.e. in the form of a mathematical model. Meanwhile, the activities in the vertical mathematization process area. Using different mathematical representations; b. Using formal symbols, languages and mathematical processes; c. Adjusting and developing mathematical models, combining model; d. Make a mathematical argument; e. Generalize [7].

Activities that include horizontal mathematization are identifying the specific mathematics in general context, schematizing, formulating and visualizing a problem in different ways, discovering relations, discovering regularities, recognizing isomorphic aspect in different problems, and transferring real-world problems to known mathematical models. While that includes vertical mathematization activity is adjusting models, using different models, combining and representing a relation in a formula, proving regularities, refining and integrating models, formulating new mathematical concepts and generalizing [8].

![Mathematization Diagram]

**Figure 1.** Cyclical characters mathematization.

Based on figure 1 the process of mathematization have cyclical characters: understanding the problem, formulating the mathematical model of the problem, solving the problem stated in the model, and interpreting the solution in terms of the original problem [9]. The first two steps change the real problem into a mathematical symbol called horizontal mathematization, the third step takes on vertical mathematization. The fourth step of changing the solution of mathematical symbols to realistic solutions is a process of horizontal mathematization. Thus, there is a relationship between the stages of problemsolving with the process of horizontal and vertical mathematization. Students are not the only difficulty in solving problems but in solving problems there is a process of mathematization which may have difficulty as well.

Widianto's research revealed that students of high and medium ability through all indicators of horizontal mathematization, but not with vertical mathematization. while low-ability subjects do not go through a horizontal process that does not represent problems in different ways and does not look for language relationship problems with mathematical symbols, whereas vertical mathematization does not adapt and develop mathematical models, and does not combine models [10].

Geometry is one of the topics in learning mathematics that is difficult. learning geometry requires a high level of thinking. The stages or mental development of students in understanding the geometry are visualization, analysis, sorting, deduction, and accuracy (rigor) [11]. Learning geometric properties of two dimensions and three dimensions, and also the development of geometric properties. As a result, achievement of student achievement on low geometry material. Based on the report of Trends in International Mathematics and Science Study in 2011 indicated that Indonesia obtained an average mathematical score of 377 on geometry material [12]. Indonesia is ranked the bottom three of all the countries that joined. The low achievement of students in geometry material is possible due to the low geometry problem-solving. Based on the low achievement of students in Indonesia about the material geometry, it is very important to do research related to the difficulty of mathematization process in solving realistic problems related to geometry material. This activity is to identify the difficulty of horizontal mathematization and vertical mathematization of students in solving problems.
2. Method
This research design using a qualitative approach with descriptive type. The purpose of this study was to identify students’ mathematization competencies in solving geometric problems. This research procedure is based on problem analysis and problem-solving nuance. The test instrument in this study is a test for identifying students mathematization competencies to solve problem in geometry. The subject is five students. The data were collected in Grade VIII of Junior High School in Surakarta the academic year 2017/2018. The data used in this study is the primary data. This means that data derived from the results of data mining by the testers themselves. The technique of data collecting done by giving write test to the student, the data analysis begins by reviewing the overall data consisting of written test result data and interview transcripts. In conducting a written test, students do not use a calculator or other electronic devices. During the test, the students were told that this test does not affect their assessment, so the feel free to express their answer based on what they think. One item problem was given to the students that can be seen below:

In the picture on bellow is a plan of a park. The middle part of the park has a fountain and on the four corners is planted with flowers, while the rest will be made by using tiles. If the cost of installing is Rp. 15,000,-/m². How many rupiahs do you have to pay for installing the tile?

![Figure 2. Floor plan of the garden.](image)

3. Result and discussion
The following are an example of answers done by the student, after being identified by the type of error will then be identified according to the difficulty that is suspected to be the cause or source of the occurrence of the error. There are five students as a research subject then generated as S1, S2, S3, S4, and S5.

3.1. Answer the problem from S1

![Figure 3. Photograph of answer the problem from S1.](image)
Based on Figure 3 does not write what is known in the problem. according to his intuition, S1 look for the area to be installed tile is a square area minus the area of a circle. S1 cannot transfer problems to mathematical models known to be in trouble. It can be concluded that the mathematization competency of student difficulties in the horizontal mathematical process. S1 writes the area of a square is 90 and the area of a circle \( \pi \) multiplied by \( d \). besides students cannot adjust the model, students do not accurately represent the formula. It can be concluded that student experience difficulties in vertical mathematization.

3.2. Answer the problem from S2

Based on Figure 4, the S2 does not write down what is known in the problem and what is asked in the problem so that S2 does not transfer real-world problems to mathematical models. This can be concluded in horizontal mathematization students experiencing difficulties.

S2 is wrong in writing the circle formula. According to intuitive S2, find the relationship between square and circle area and four quarter circle to find the area to be tiled, but S2 does not combine and represent relationships in a formula to find the area to be installed in the tile. So that student has difficulty in vertical mathematization.

3.3. Answer the problem from S3

Figure 5 shows that S3 identifies mathematical problems in a general context, but is confused about writing what is meant by 7 m in the picture. S3 has difficulty in transferring real problems to mathematical models. S3 has difficulty in horizontal mathematization.

S3 has correctly written the formula for the area of a square, the area of a circle of fountains but incorrectly writes the length of the radius of a circle. Based on the S3 intuition, finding the area to be installed in a tile is the area of a square minus the area of a circle, ignoring the area of four quarter circles. It can be concluded that students have difficulty in vertical mathematization because S4 does not find models, find the order, perfect and integrate models.
3.4. Answer the problem from S4

Figure 6 shows S4 does not write down what is known in the problem and what is asked in the problem so that S4 does not transfer real-world problems to mathematical models. This can be concluded in horizontal mathematization S4 experiencing difficulties. S4 intuition that the area to be installed by tile in the area of the square minus the circumference of the circle. The length of the square side based on S4's thinking is 120m. It can be concluded that S4 does not adjust the model, combines and reflects the relationship in the formula and does not perfect the model correctly.

3.5. Answer the problem from S5

Figure 7 shows S5 does not write down what is known in the problem and what is asked in the problem so S5 do not transfer real-world problems to mathematical models. This can be concluded in horizontal mathematization students experiencing difficulties. S5 has an intuition that the area to be installed in tiles is a square area added by a circle edge and added 7m. It can be concluded that S4 does not adjust the model, combines and reflects the relationship in the formula and does not perfect the model correctly.

Based on the answer from five students do not use abstract symbols to write what is known and what is asked in solving the problem. Because students have difficulty in horizontal mathematization then the difficulties in vertical mathematization. Allegedly students do not understand the meaning in the problem The process of mathematization is cyclic, if students do not understand the problem then the students will have difficulty in modeling mathematics, solving model and interpretation [9]. In vertical mathematization, students use the wrong formula, meaning students cannot determine the correct mathematical model, wrong in connecting formula one with another formula to find a solution to a problem which means students find it difficult to combine and represent a relationship in a formula so students do not combine formulas correctly, and students have difficulty integrating mathematical models. besides difficulties in modeling, all difficulties in the calculation. it seems that many students make miscalculations. the students do not adopt the model, do not use different models, do not merge and represent relationships in a formula, and do not refine and integrate models [8].
4. Conclusion
The student must know the difficulties when he/she solves the geometry problem so that the student can reflect on the difficulties experienced. This study distinguishes the difficulty between horizontal and vertical mathematization so that students and teachers can know which parts are difficult in solving geometric problems that are understanding the problem, and formulating a mathematical model of the problem that is horizontal mathematization and solving the problems stated in the model and interpreting the solution in terms of the problem originally a vertical mathematization. This research concludes that in horizontal mathematization students difficulties in discovering relation and transferring the real-world problem to known mathematical models. Difficulties on vertical mathematization are adjusting models, combining and representing a relation in a formula, and refining and integrating models.

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