How to Solve Polyhedron Problem?

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Abstract. The purpose of this research is to know the possible strategies to solve the problem in polyhedron topic with Knisley’s Learning Model as scaffolding for the student. This research was conducted by using mixed method with sequential explanatory design. Researchers used purposive sampling technique to get two classes for Knisley class and conventional class and an extreme case sampling technique to get interview data. The instruments used are tests, observation sheets and interview guidelines. The result of the research shows that: (1) students’ strategies to solve polyhedron problem were grouped into two steps: by partitioning the problem to find out the solution and make a mathematical model of the mathematical sentence given and then connect it with the concept that the students already know; (2) students’ mathematical problem solving ability in Knisley class is higher than those in conventional class.

1. Introduction

Polyhedron is one of the compulsory materials for every level of education in Indonesia, but many students are still have difficulty to solve the problem in this topic [1]. Polyhedron topic in secondary level includes the activity to know the elements of cube, cuboid/rectangular prism, prism, and pyramid, make the net of polyhedron and solve problem-solving problems related to surface area and volume based on latest curriculum.

Problem solving in mathematics becomes important because problem solving and mathematics are two things that can not be separated [2], and problem solving is not an applicative end-goal of the material given, but rather the center of mathematics activities [3]. However, the problem solving ability of secondary school students is still relatively low [4]; [5]; [6]; [7]. This is also supported by Fakhrudin's research (in [8]) which states that in general, the result of mathematics problem solving ability test of junior high school students has not satisfied, that is about 30.67% from ideal score 100.

To solve the students’ difficulties in solving polyhedron problem, the student need tool which can give scaffolding for the student [9]. Based on the study that has been done, Knisley’s learning model is appropriate to assist students in the process of mathematical problem solving because Knisley’s learning model has syntaxes that prioritizes interaction and scaffolding which allows teachers to perform activities based on the needs of students with group discussions and class discussion [10]. In addition, in the learning process, Knisley’s learning model includes exploration, translation and confirmation activities so that the model has advantages: (1) generative (2) supports memory (3) reduces the need to remember (4) enhances transfers and affects confidence. This was stated by Hiebert and Carpenter [11]. Furthermore, in this research Knisley’s learning model being a tool for the
student to find strategy to solve polyhedron problems. Based on this exposure, then the formulation of the problem as follows:

(1). What strategies do students use to solve polyhedron problems?

(2). Is the mathematical problem solving ability of students who worked under Knisley's learning model higher than students who worked under conventional learning models?

1.1 Polyhedron Problem

The goals of the research is students' problem solving ability on polyhedron topics. Problems assigned to students relate to the surface area and volume of cube, cuboid/rectangular prism, prism and pyramid. Baykul [2] state that problem is a condition when one is asked to find a solution based on his knowledge and experience. Based on the definition [2], Altun [12] concludes that there are three characteristics of difficult problems, they are: give desire to find the solution, difficult to find the solution at first sight, and can not solved by routine procedure.

Viewed from the type of the solution, the problem can divided into open and closed problems. A closed problem is a mathematical problem that has one solution, and open problem has many solutions [13]. Meanwhile, when viewed from the process to get the solution, the problem is process of transformation associated with the mathematical sentences [14]. LeBlanc [15] categorizes mathematical problems as routine and nonroutine problem. A routine problem can be solved by only one step, while a nonroutine problem need strategy, nonroutine procedure and many ways to get solution. Problem in this research nonroutine problem with close solution and open solution. The example of the problem is as follows: "Total area of quadrilateral prism net is 484 cm². Determine the length, width, and height of the quadrilateral prism in your own way? Is there any other way or any other size that you can get? Please check the truth of your answer!"

The indicators of problem-solving abilities in this study are based on four Polya’s problem-solving steps: (1) Understanding the problem: identifying the elements that are known, questioned, and the adequacy of the necessary elements; (2) Planning for problem solving: developing mathematical models or selecting and arranging; (3) Implementing the plan: the execution of the settlement plan so as to obtain the correct solution; (4) Looking back: an activity to examine the truth of the answers and explanations, or interpretation of the results [16]

1.2 Knisley’s Learning Model

Knisley’s learning model is a learning model developed by Jeff Knisley which was later published in a scientific journal in 2002. The Knisley’s learning model is a development and adaptation of the experiential learning model from Kolb [10]. The interesting thing from this learning model is the existence of alternate activeness pattern between student and teacher which is expected to create good interaction situation so that it can support the development of students problem solving abilities in mathematics. The syntaxes of Knisley’s learning model are concrete-reflective, concrete-aktive, abstract-reflektive, and abstract-active.

In concrete-reflective, a new concept is described through familiar things to the concept that students already know. However, at this stage students can’t distinguish between new concepts with a concept that already know. In concrete-active, the process of comparing, measuring and exploring is used to distinguish new concepts and old concepts. At this stage, the students have started to use the concepts that have been known but they do not know the connection between knowledge that has been known so that they begin to act with trial and error. In abstract-reflective, the new concept has become part of the basic knowledge, the student has begun to understand the association of the new concept with the old concept which they already knew, the information they began to need to do something with a known concept with detailed explanations. In abstract-active, students have been able to use known concepts to build strategies in solving the problem, perform operations and judgment on the strategy that has been done [10]. In these four syntaxes, teachers have different tasks, in the concrete-reflective phase the teacher has a role as a storyteller, in concrete-active teacher acts as a mentor and
motivator, in the abstract-reflective stage the teacher acts as an informant and at the abstract-active stage the teacher acts as a coach [11].

1.3. Relevant Research

Research of polyhedron has been done by some mathematics education researchers, especially regarding the effort of enhancement students’ ability on polyhedron topic ([17];[18]; [19]; [20]). In addition, some researcher are also studies of students’ creativity, difficulties and mistakes in polyhedron topic ([30]; [21]; [22]). Speaking about Knisley’s Learning Model, the research on this model was done by Mulyana in his dissertation in 2009 in relation understanding ability and mathematical disposition. In subsequent years, research on Knisley’s model of learning by Haety and Mulyana on mathematical connection skills of students in senior high school (2013); The influence of Knisley's learning model with brainstorming method on strategic competence and mathematical disposition of students [23]; The influence of Knisley's learning model on mathematical communication ability of elementary school students [24]; And comparison of mathematical relationship between learning model of Discovery Learning with Knisley’s learning model [25]. However, during the research conducted by the researchers, there has been no research on how to solve polyhedron problem with Knisley’s learning model as a tool of scaffolding. This is the novelty of the research.

2. Method

The goals of the research were to find out the ways that students use to solve problem in polyhedron topic and to know students’ problem solving ability of this topic, so that the research method chosen was mixed method. Research design used in this research was sequential explanatory design. The characteristics of a sequential explanatory research design was found in mixed methods with quantitative data collection in the first stage followed by qualitative data collection in the next stage [26], quantitative and qualitative data analyzed separately [27].

In the quantitative phase, population in this research were all eight grader students in one of the secondary school in Ciamis, West Java. Sample consisted of two classes selected based on purposive sampling technique [28]. Meanwhile, the sampling technique used to obtain interview data is an extreme case sampling technique [27].

The research procedure consists of preparation, execution and final stages. The preparation stage consists of identification of the problem, preliminary observation, instrument making and instrument testing. Phase of the research implementation lasted for two months including pre-research activities, pretest, learning activities, postest and interviews. While the final stage consists of activities of data collection, analysis and conclusion.

3. Result and Discussion

In this section, we will discuss the results of research related to research objectives. The purpose of the research is to find out the students’ ways to solve polyhedron problems and to determine the mathematical problem solving ability of students who worked under Knisley’s learning model compared to students who worked under conventional learning model.

Based on research reports and observation results, it is known that at the first meeting the students still look confused to find a strategy. However, at this time the teacher acts as a facilitator by using the Knisley’s learning model as a tool to help students with interaction between teachers and students. Using the Knisley’s learning model in group discussions, students are seen beginning to understand how to think about problem solving strategies using Polya steps in group discussions.

At subsequent meetings, teachers provide polyhedron issues related to the concept of trigonometry and algebra with increasing complexity levels to a higher level at each meeting until reaching the sixth meeting. From these six meetings, the researcher can classify the student's way of solving polyhedron problems into two ways: partitioning the problem into smaller partitions and make the mathematical model of the mathematical sentence given by building the connection between the questions given by
teachers with the concepts that students already know. Example of problem: A rectangular pyramid with length of base is 13 cm and the height is 17 cm will made from 261 cm of wire. Make another prism from the remaining wire with the height is 25 cm and the side’s ratio of triangle is 5: 4: 2 respectively!

![Figure 1. Students’ Answer for Problem 2](image)

**Figure 1. Students’ Answer for Problem 2**

Figure 1. shows that the student try to make partition of the problem, making mathematical model and find out the answer. Another goals in this research is about students’ mathematical problem solving ability. Result of the treatment in Knisley class and conventional class as follow:

![Graph](image)

**Figure 2. Result of Pretest-Postest in Knisley group and conventional group**

Figure 2. shows that the average pretest grade of the Knisley group is higher then conventional group and the score was 8.35 and 8.76, but the result of statistical tests showing that the average of the students’ grade of the experimental group and the control group does not differ significantly. The average postes grade of Knisley group is higher than conventional group in score 23.65 and 16.21 from Ideal Score 50 with the result of statistical test showed that the average score of Knisley group was higher than the average of the conventional group score. It means that Knisley’s learning model success for being a scaffolding to help students’ in polyhedron problem so because of four syntaxes that it have, they are: concrete-reflective, concrete-active, abstract-reflective, and abstract active. One of the most powerful syntax in Knisley’s learning model is abstract reflective. In abstract reflective, teacher can give scaffolding to the student who has difficulties to solve the problem. It makes the student doesn’t give up when they have no idea or strategy to solve it, so the student being confidence to learn problem solving in mathematics.
Although students' mathematical abilities in solving polyhedral problem based the scores has not yet reached the high category, the students' specific abilities in some indicators of problem solving have been excellent, especially in understanding the problem and planning the strategy. This is evident from the activities of students in group activities that are active in conducting trials and errors when given the task of creating a unique nets of solid and in other problem solving activities. The students also have been able to understand that problems have a nonroutine strategy and has many solutions at an active abstract stage when students convey the solution of the problems provided through the worksheet. The students were so confidence to express their opinions and believe that the strategies and solutions they get are correct even though the results are different from the other groups. The weakness of students in problem solving activities is at the stage of doing the plan and looking back.

In the implementation stage, the students often do mistake in calculate that are closely related to the failure to conduct looking back. Many students are reluctant to do looking back process at the start of the research even though in the end of research some students have been able to understand and carry out looking back activities.

4. Conclusion
The conclusions of this research are as follows.
1. There are two steps of strategy that students used to solve the polyhedron problem, first step is by partitioning problem to find out the solution and second steps is make a mathematical model of the mathematical sentence given then connect it with the concept that the students already know.
2. Mathematical problem solving ability of students who worked under Knisley’s learning model is higher than students who worked under conventional learning model because the Knisley’s learning model have syntaxes that prioritizes interaction between teachers and students and emphasizes on giving the right scaffolding when the students difficulty in the process.

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