Students’ Problem-Solving Ability in Temperature and Heat Concepts

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Abstract. This study aims to determine the problem-solving ability on the topic of temperature and heat. This research is a survey research. The subject of this study consisted of 118 undergraduate physics education program students' (46 first-year students, 29 second-year students, and 43 third-year students). The research instrument consisted of 4 essay question questions. The results of the analysis show that students' ability to solve problems about temperature and heat is still in the 'novice' category. In solving the problem, 13.56% of students have completed the Visual Representation stage, 68.22% of students have completed the Describe The Physics stage, 79.45% of students have completed the Plan A Solution and Execute The Plan stages, and 22.67% of students have completed the Evaluate The Answer stage. Most students only use mathematical equations without understanding their meaning.

1. Introduction

Problem solving ability is an important goal that must be achieved in learning natural sciences [1], technology and the application of mathematics [2]. The nature of physics consists of four main elements, namely attitudes, processes, products and applications. From the nature of physics as a process, studying physics means carrying out all scientific activities to gain knowledge about nature. The activity of gaining knowledge includes to solving the problems related to natural phenomena.

Problem solving ability are absolutely needed by students and its one of the demands in the 21st century [3]. This ability is not only needed in physics learning but also in everyday life [4]. Problem solving skills are the most complex intellectual skills, thinking skills, and the highest cognitive strategies. Therefore students' problem solving skills need to be explored to help students become problem-solving experts in physics and in everyday life.

Many researchers have examined students' problem solving abilities on various topics. Such as, examining students' problem solving abilities on the topic of simple harmonic motion [5], examining students' problem solving abilities on the topic of mechanics [6]. But the ability to solve student problems on the topic of temperature and heat is very rarely studied in Indonesia. On this topic most researchers focus on content knowledge in the form of conceptual understanding [7] and misconceptions [8–10] experienced by students.

Students' problem solving skills need to be identified. If students' problem solving abilities have been identified then the weaknesses of these abilities can be given a solution by training them through...
appropriate learning. Based on these needs, research is conducted which aims to identify the problem solving abilities of students on the topic of temperature and heat.

Problem solving ability when viewed from a psychological point of view is part of the information processing theory. According to this theory there are three important components involved in problem solving namely content knowledge, working memory, and long term memory [11]. Content knowledge is a component that determines a person can solve a problem, if analogized then content knowledge is a basic material that can be used to solve a problem, while long term memory is where the storage of content knowledge, and working memory is where information is processed (including content knowledge) to solve a problem.

Problem solving skills can be seen from the general strategies used in solving problems. There are some experts who express opinions regarding problem solving strategies, among them are Polya [12], Heller [13], Reif [14] and Docktor. The problem solving strategies expressed by the policy are more likely in the field of mathematics, while others are specific to the field of physics. In this study the problem solving strategies used to assess students' problem solving abilities refer to the opinion of Docktor (2009). According to Docktor [15] general strategies in solving problems include visual representation, physics description, plan a solution, execute the plan, and evaluate the answer.

2. Method

This study aims to determine students' problem-solving abilities. The study was conducted on 118 students who were 24 graduate students and 94 undergraduate students (22 first-year students, 29 second-year students, and 43 third-year students). This research was conducted using 4 essay questions which were standard test questions at Malang State University which were developed to measure students' problem-solving abilities. All students who were used as research subjects had participated in basic physics 1 and had discussed the topic of temperature and heat. Data obtained from student answers were analyzed using the rubric that had been developed by Docktor [15].

3. Result and Discussion

Analysis of students problem-solving steps use the rubric that was adapted from Docktor [15]. Based on the results of the analysis obtained data on the ability to solve student problems on the topic of temperature and heat as shown in Table 1.

| Steps of problem-solving ability                      | %        | Average of percentage |
|-------------------------------------------------------|----------|-----------------------|
| Visual representation                                  | 9.32     | 4.4                   | 30.51 | 10.17 | 13.56 |
| Describe the physics                                   | 75.42    | 82.20                 | 66.10 | 49.15 | 68.22 |
| Plan a solution and execute the plan                   | 89.83    | 91.53                 | 66.10 | 70.34 | 79.45 |
| Evaluate the answer                                    | 7.63     | 15.25                 | 19.49 | 48.31 | 22.67 |

Based on Table 1, the average percentage of students completing the visual representation stage is 13.56% students. The form of visual representation used in both items is generally in the form of picture and graphics, but the picture and graphics presented are conceptually false. Visual representation can be influenced by conceptual understanding.

There were 68.22% of students completing the Describe the Physics stage, this meant that 31.78% of students were unable to describe the problem in physics. At this stage the average student writes out known and asked variables on the problem without verbal explanation. But the variables written by students are not complete and not in accordance with the conditions given in the question. The stage of the plan solution and execute the plan was only passed by 63.98% and 79.45% of the students as a whole. All students who go through the plan the solution stage plan problems by writing physics formulas,
while the execute the plan stage is implemented with a mathematical approach and generally only plug-and-chug. Students who solve problems using mathematical equations without understanding their physical meaning will not be able to develop their abilities in solving more complex problems [16].

The last step in solving the problem is Evaluate the Answer. Based on the survey results, only 22.67% of students went through this stage as a whole. This shows that only a few students realize the importance of evaluating answers in the problem-solving process. Apart from being concerned with accuracy, evaluating answers is also important to ascertain whether the solution we have given is correct or not.

When viewed from the percentage of students who go through the stages of problem solving, students' problem-solving abilities are said to be still low and classified as a novice problem solver. The novice problem solver tends to start solving problems by writing equations that match what is known from the problem [17]. Unlike the expert problem solver that starts solve problems by describing the problem qualitatively first.

Failure of students to solve problems is not caused solely because they do not have the relevant knowledge of the problem, but often due to the failure of students to activate the knowledge they have in their long-term memory [18]. To help students succeed in solving problems with problem solving skills such as expert problem solvers, appropriate learning activities are needed to train them, of course with learning activities that train and help students quickly access the knowledge that has been stored in the long-term memory.

4. Conclusion

Based on the results of the identification of students' problem-solving abilities on the topic of temperature and heat, it can be concluded that students at Malang State University are still in the novice problem solver category, and the problem-solving ability that is owned is low. Further research related to the ability to solve problems on the topic of temperature and heat is still needed, especially in the application of learning strategies that facilitate students to improve their problem-solving abilities.

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