Types of junior high school students errors in science problem solving

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Abstract. This research aims to identify the errors of junior high school students in Science problem solving. This study is a descriptive research with quantitative and qualitative approach. The subject of the research is 30 students of class 8C SMP Negeri 2 Singaraja that made mistakes in a test of Science problem solving. The sampling was conducted with a test of problem solving and interview. The research data is a description of the source, type, and causative factor of the errors done by the students in solving Science problem on temperature and heat material. The data was analyzed descriptively and qualitatively. The result of the analysis shows that a lot of students made errors in performing problem solving strategy, which are: (1) understanding problem 58, 12%; (b) planning problem solving 55, 15%; (c) executing plan 70, 18%; and reviewing 85, 7%. The types of errors done by the students are: (1) concept/misconception error, (2) linking between concepts, (3) principle error, and (4) error in writing the corresponding unit. Furthermore the causative factors of the errors done by the students are: (1) poorly trained in solving problem; (2) habitually doing routine tasks; (3) being incomplete/incorrect in writing what is known and asked; (4) did not understand with the requirements of the questions; (5) the use of incorrect formula; (6) being inaccurate; (5) forgot the concept; (6) unable to give reasons; and (7) did not do a review toward the problem solving result.

1. Introduction

Science Education in 2013 curriculum has an intention to make students understand about the concepts and the relation between concepts, being able to communicate, and applying the concepts to solve problems, whether academic problems or problems in daily life [1]. The purpose of science education beckons problem solving is based on the concept comprehension and its linkages, communication, and uses strategy in problem solving. The learning in problem solving nuance is urgently done, considering the quality and quantity of students’ ability to understand concepts, solve problems, and communicate are the keys of science learning and parts of the main component in supporting science learning in 21st century [2].

Problem and problem solving are important aspects in science learning, because problem and problem solving are used to teach students in applying knowledge and skill they obtain in learning process [3][4]. Problem is different from task or routine question. If a problem given to a student and the student knows how to correctly solve it right away, then the question cannot be said as a problem.
Someone deals with a problem when there is a gap between current condition with the goal intended to be achieved, while it is unknown what must be done to achieve the goal [5][6][7]. Problem is a situation experienced by someone so that what he has experienced is different from what he wants [8][9]. Based on the points of view, it can be described that problem emerges because there is a gap between expectation with reality, what is owned with what is needed, what has been known with what people want to know.

The fundamental difference between doing of routine questions/exercises with problem solving in learning physics located at the solving process. In the completion of routine tasks/exercises, students are only required to immediately get the answers, for example counting by inserting the numbers into formulas, the operation of sum and multiplication of vectors, and so on. Problem solving in physics is when a student is unable to find out the solution right away, but the student needs to reason, guess or predict, and look for the simple concept or formula and then prove it. According to [3][10], the characteristics of a problem is it needs the power of thinking/reasoning, challenges students to figure out the concept and its relation, guesses/predicts the solution, how to get the solution, and it must be proved that the achieved solution is correct/right.

Problem can be solved with various steps in accordance with the context of the problem. According to [3][10] there are five steps in problem solving strategy, which are recognize the problem, describe the problem in terms of the field, plan a solution, execute the plan, and evaluate the solution. The recognition of a problem can be developed with qualitative description in form of pictures or words that can help students in finding the subject matter. In describing a problem, students can simplify the issue in its physical form and submit useful contexts. In planning a solution, students can make an equation structure based on the contexts submitted in the previous step. In executing the plan, students can manipulate the equations, insert discovered variables. Lastly, students have to evaluate the answers, which is by examining the errors and assuring that the answers have been met.

Problem solving requires completion steps or rules. Several problem solving steps are, [11] suggested problem solving steps through understanding the problem, qualitative analyzing of the problem, solution plan for the problem, applying the solution plan, and checking. [10] proposed problem solving steps through define the problem carefully, explore possible solutions, narrow your choices, and test your solution. [12][13] suggested problem solving steps through understanding the problem, devising a plan, carrying out the plan, and looking back. Taking a close look toward the problem solving steps, it seems that the arrangements of problem solving steps in science (physics) are: (a) understand problems which include concept comprehension and its linkages, (b) plan a solution that includes identifying and relating between variables, writing corresponding scale and unit system, describing solution sketch (picture, diagram, graphic), and establishing solving strategy (concept, formula, mathematical algorithm approach), (c) executing solving plan, (d) reviewing problem solving results and steps which include the use of alternative problem solving strategy, concept relevance and validity, concept/formula understanding, corresponding scale and unit, and mathematical algorithm. Based on the problem background, then the problem studied in this study is how are the types of errors done by junior high school students in solving science problems?

2. Method
This study is descriptive research type with quantitative and qualitative approach. The subject of the research is 30 students of class 8C SMP Negeri 2 Singaraja which got selected randomly by using intact group.

The instrument used in this research is written test which are questions about problem solving and interview guideline. The instrument in this research consists of 5 essay questions about problem solving on teaching materials of temperature and heat. The research instrument was validated by three validators, which are two lecturers of Universitas Pendidikan Ganesha of physics education study program and one science Junior High School teacher with the validation result that the applied instrument met the validation content and construction. Based on the instrument test result,
information is achieved that the level of arranged problem reliability is classified to be reliable with reliability coefficient 0.73.

The data collection was conducted with a test of problem solving and interview. The resulting data is a description of the source, type, and causative factor of students made errors in solving science problems in temperature and heat material. The data was analyzed by using error percentage descriptively and using Miles and Huberman’s analysis stages qualitatively, included: data collection, data reduction, and verification.

3. Result and Discussion

3.1. Result

The analysis result of students’ errors in science problem solving (physics) is located at the problem solving strategy stages, which are: errors in understanding problems, planning a solution, executing the plan, and errors in reviewing the result and steps of problem solving. The error percentage of students on each temperature and heat solving stage is presented on Table 1.

Table 1. The Error Percentage of Students on Each Stage of Science Problem Solving (Temperature and Heat)

| Problem Solving Stage       | No. Problem and Percentage of Problem Solving Errors | Average |
|-----------------------------|-----------------------------------------------------|---------|
|                             | 1          | 2         | 3         | 4         | 5         |         |
| Understanding Problem       | 68,76      | 77,36     | 82,14     | 80,18     | 85,10     | 78,71   |
| Solution Plan               | 57,15      | 60,35     | 72,11     | 70,68     | 82,22     | 68,50   |
| Plan Execution              | 71,12      | 75,20     | 80,17     | 76,15     | 78,47     | 76,22   |
| Review                      | 80,25      | 78,83     | 81,15     | 79,80     | 82,53     | 80,51   |

The average trend of students error percentage on each stage of problem solving is described in graphic form as shown in Picture 1.

Based on the percentage of students errors in problem solving shown in Table 1 and graphic on Picture 1, it can be interpreted that most students errors in science problem solving (teaching materials of temperature and heat) are located on the review (PK), followed by mistakes in understanding problems (MM), executing plan (PR), and then making problem solving plan (RP).

The analysis result of the interview with 15 students reveals a type of students’ errors in problem solving stages as shown in Table 2.

Table 2. Type and Percentage of Students Errors on Science Problem Solving Stage (Temperature and Heat)

| Error Type on Problem Solving Stage | No. Problem and Percentage of Error Type in Problem Solving | Average |
|------------------------------------|-------------------------------------------------------------|---------|
|                                    | 1          | 2         | 3         | 4         | 5         |         |

Picture 1. Percentage Graphic of Students Errors in Problem Solving
1. Understanding Problem
   (a) Identify concept
   (b) Link between concepts
   (c) Misconception

2. Solution Plan
   (a) Identify variable
   (b) Determine the relation between variables
   (c) Write the suitable scale and unit system
   (d) Describe solving sketch (picture, diagram, graphic)
   (e) Establish solving strategy (concept, formula, mathematical algorithm approach)

3. Plan Execution
   (a) Implement the plan in problem solving

4. Review
   (a) Use alternative strategy in problem solving
   (b) Concept relevance, linkages between concept/formula, corresponding scale and unit, and mathematical algorithm
   (c) Not done

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The analysis result presented on Table 2 can be interpreted that the types of students’ errors on each stage of problem solving are. (1) The type of students’ errors in understanding problem stage, most students experienced misconception, followed by mistakes in linking between concepts, and identifying related concept with problem. (2) The type of students errors in planning problem solving stage, most students did mistakes in determining the relation between variables, mistakes in establishing solving strategy (concept, formula, and mathematical algorithm approach), mistakes in identifying variables, and mistakes in writing the corresponding scale and unit system. (3) The type of students’ errors in plan execution stage, most students were incorrect in implementing plan. Problem solving plan that has been appointed does not fit with the implemented one; and (4) The type of students errors in review stage, most students did not do it and were incorrect in applying relevant concept, linkages between concepts/formulas, suitable scale and unit system, and mathematical algorithm, then followed by mistakes in using alternative problem solving strategy.

### 3.2 Discussion

The analysis result of student’s errors in science problem solving is located at the problem solving stages with different types of errors. This analysis result is suitable with the research result of [12][11] which found out that the struggles of students in solving motion problems are located at the problem solving stages, which are: stage of understanding concept, planning a solution, and executing the solving plan. [13] also figured out the struggles of students in solving rotation and torque problems are located at the problem understanding, problem solving planning, and the review of problem solving steps and result.

The students errors on the problem solving stages are caused by several factors, which are: (a) students are lack of training and not get used to with solving problem, (b) the problem representation presented in the learning process is limited to routine questions which use formulas to solve them, (c)
Mathematical misconception and operation. The following three factors affect the other errors, which were done by the students in problem solving stages. In the effect of training factor, [12] said a child who is given a lot of problem solving exercises, has higher grade in problem solving test compared to those who are lack of trainings. [11][14] also said the more problems that can be solved by a student, the more skills he will have that can help him to solve problems in daily life. In the effect of problem representation, [3] said, learning problem solving is essentially learning how to think or reason to apply the knowledge that have been obtained before, in solving new problems that never been encountered. In problem representation, [11] said, students who are studying science and wonted with non-routine questions or problems, these students will be skilled by applying various concepts in new situation, so they will be able to use various concepts of science that they have learned to solve problem in daily life. In the effect of misconception, [5] proposed that misconception is a form of delusion, which is a supposition of the true one, is false and the false one is true. This delusion can have the shape of a wrong understanding, a mistake, or cognitive disorder of students. [5][15] explained, students who experience misconception can influence the concept understanding, between-variable linkage, and concept application in problem solving.

4. Conclusion
Students’ errors in science problem solving (physics) are located at the stages of executing problem solving strategy, which are: mistakes in understanding problem, planning a solution, executing solving plan, and mistakes in reviewing the result and steps of problem solving. The type of students errors on each problem solving stage are: (1) the type of students errors in understanding problem stage, most students experienced misconception, followed by mistakes in linking between concepts, and identifying related concept with problem; (2) the type of students errors in planning problem solving stage, most students were incorrect in describing solving sketch (picture, diagram, and graphic), followed by mistakes in determining the relation between variables, setting solving strategy (concept, formula, and mathematical algorithm approach), identifying variables, and writing the corresponding scale and unit system; (3) the type of students errors in plan execution stage, most students were wrong in implementing plan. The established problem solving plan are not corresponding with the implemented one; (4) the type of students errors in reviewing, most students did not do it and were mistaken in applying relevant concept, linkages between concept/formula, suitable scale and unit system, and mathematical algorithm, then followed by mistakes in using alternative problem solving strategy. Based on the result of this research, many students did various mistakes in solving science problems presented in learning. Therefore, Math and Science teachers are expected to perform learnings by emphasizing problem solving training. Problem solving skill is very important to be mastered by students when they plunge into society.

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