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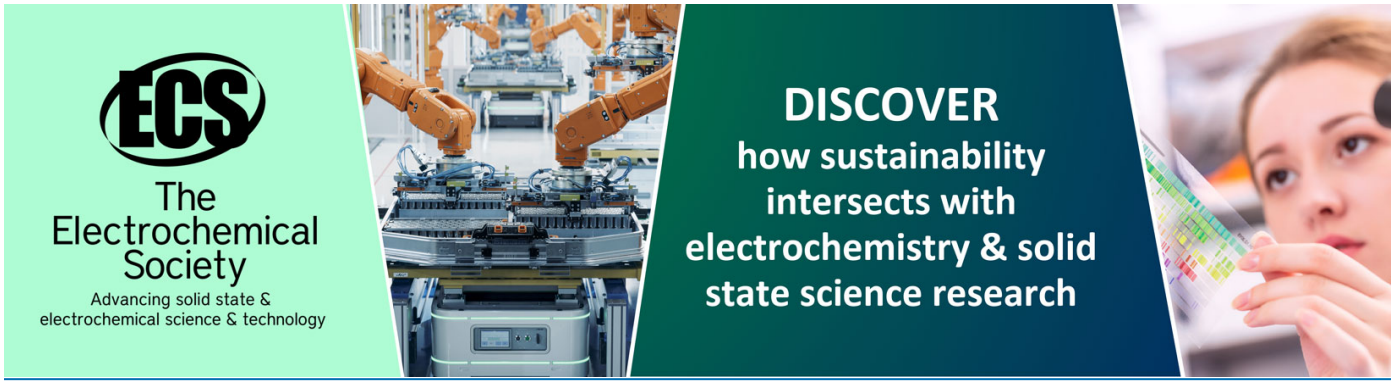

On values in non-routine mathematical problems for senior high school students

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Abstract. This study aims to describe values in non-routine problems for senior high school students. This research used the qualitative method. The subjects of this study were the senior high school students. The data collection techniques used interviews and observations. An interview was used to get information about curriculum and the abilities of the students. The observation was used to find out the mathematical values contained in the non-routine problems. The results of the study show that in non-routine problems there are values that exist in mathematical values. These values are rationalism, objectivity, control, progress, openness, and mystery.

1. Introduction

There are two types of problems in mathematics, namely routine and non-routine problems [1]. In solving routine problems, also known as drill exercise, the students apply routine completion procedures that concern to familiarize them to apply that certain procedures appropriately. While in solving non-routine problems, the students construct more complex and uncertain procedures [1,2]. In other words, this non-routine problem presents a new situation that has never been met by the students. In this new situation, the goals are clear, but the way to achieve them does not immediately appear in the students' minds, on the contrary to routine problems, because of non-routine problems require [2]. Both types of these problems, especially non-routine problems, are appropriate to develop mathematical problem-solving skills.

However, the students' abilities to solve non-routine problems are still low [3,4]. Likewise, with the students who solve problems developed based on PISA test, they are able to solve questions at level 1 until 3, but many still experience difficulties at level 4 until 6 [5]. Almost 80% of Indonesian students are at level 2 [3]. At levels 1 to 3, the students still use simple strategies, while at levels 4 to 6 they use more complex strategies [5]. This means they are able to work on routine problems, but experience difficulties in non-routine problems. In addition, the students' metacognitive abilities in solving non-routine problems are only at the middle level [4]. Likewise, when working on non-routine problems in the field of geometry, only the students with high abilities can solve the problems well. Meanwhile, the students with low and moderate ability have not succeeded in completing the problems [6]. Investigation of the students' difficulties completing non-routine questions shows that they are weak in reading, interpreting problems, and re-checking their work [7].

The poor performance of the students in completing non-routine problems in this PISA test has been anticipated by asking them applying different strategies such as constructing images and tables [8,9]. The result shows that the students are not used to using images and tables, so the problems are not resolved. Besides, the students are also required to use flexibility and exploration strategies [2]. Students with flexible strategies have the ability to use many strategies and reasoning for choosing problem-solving strategies and succeed in using various strategies in different problems [2].

To solve non-routine problems, skills and strategies are needed [11]. Not only those but also values are needed. In learning Mathematics, values can be trained with worksheet [18]. It is because there are values in school mathematics [10]. These values are reflected in teaching-learning materials, learning process, problems, and mathematics solutions. There are three types of values in mathematics, namely general educational values, mathematics educational values, and mathematics values [11]. In this research, the non-routine mathematics problems based on values in high school are designed. The topic chosen is a three-variable linear equation system for senior high school students.

2. Methods

The qualitative method was used to describe mathematical values in non-routine problems [12]. The subjects of this study were the students of senior high school. The research begins by looking for literature related to non-routine problems and values in mathematics. In addition, supporting information about students, the curriculum, and materials are also collected. The first step of this research is by looking for literature related to non-routine problems and values in mathematics. In addition, supporting information about students, the curriculum, and materials are also collected. The next step is to define the values of general and mathematics education and mathematics. Activities carried out in planning formulating skills that want to be achieved.

Furthermore, non-routine problems are chosen which are expected to contain the values of general and mathematics education and values of mathematics. Those problems were solved by the students. The results of student answers are analyzed to see mathematical values.

3. Result and Discussion

From the first step –research and information collection- data was collected through interviews with a teacher. The interviewer asked: "*Can students solve the problem of three variable linear equation system*?" The teacher said: "*If the problem is routine, students can do it all. If for example non-routine ... I don't know ... questions like this* (pointing to the non-routine problems that the researcher collects) *... no know* (it looks like the teacher is worried that students cannot afford it)." From this interviews was found that students had difficulties in solving non-routine problems. The students were familiar with routine problems, but not with the non-routine problems. Besides that, it was also found that student had difficulties in change and relationship [3] or algebra [13].

In designing step, it is also necessary to analyze the characteristics of senior high school students. These students are around 15-18 years old. This age, according to Piaget, is in the formal cognitive age group of operation. The students are supposed to have been able to think logically, think with formal theoretical thinking based on propositions and hypotheses, and can draw conclusions from observations [14,15]. Theoretical thinking ability based on propositions and hypotheses shows that students are able to deal with unusual or non-routine situations. When reading a non-routine problem, the students at the beginning may solve the problems by applying straightforward procedure. But, when they experience a collision, they attempt to create a hypothesis by linking the issue to other topics they know already. Because of these students' characteristics, the learning indicators in this research are developed so that the students are able to solve non-routine problems.

The selected concept in applying values to non-routine problems in this research is the three-variable linear equation system. At the first, the core competencies, basic competencies, and indicators need to be defined. The core competency is derived from Curriculum 13 which has been revised through the Ministry of Education and Culture number 24 of 2016 [16]. This topic is in the Core Competency 3: the students "understand, apply, and analyze factual, conceptual, procedural

knowledge based on his or her knowledge of science, technology, art, culture, and humanities with the insights of humanity, nationality, state and civilization on the causes of phenomena and events, and apply procedural knowledge to specific areas of study according to their talents and interests to solve problems".

From Core Competency 3, one of the competencies that the students must have is "to apply procedural mapping to solve a problem". Related to that, the required skills as listed in Core Competency 4 are "Processing, reasoning and reciting in the real life of concrete and abstract real life related to the development of the self-study in schools independently, and able to use methods according to scientific rules". The core competencies are explained in more detail in basic competencies.

From the analysis of Core Competencies 3 and 4, it is found that the core competency or the level of ability to achieve the competency standards is to solve problems by processing and reasoning in the concrete and abstract scope. Furthermore, this ability is described again in some Basic Competence so that there are the ability and the minimal learning materials that must be achieved by students in the subjects of Mathematics in Grade X Senior High School.

In solving non-routine problems, the skills students also must possess include the value of general education, the value of mathematics education, and the value of mathematics. Therefore a non-routine problem should be designed containing these values. In this research, the non-routine questions are designed as tasks that need to be done during the learning process. In addition, the problems are also given at the time of the test.

After conducting the research phase and gathering information, the next step is to develop a research plan. It is to arrange non-routine questions based on the values in mathematics. Skills and expertise measured are the students' skills in solving non-routine questions based on the values that exist in mathematics learning. One of the non-routine problems is found in figure 1.

> Dika along with her father and grandfather are harvesting oranges in their fields. The work of harvesting the oranges can be completed within 4 hours. If Dika and her grandfather work together, then they can only finish the job within 6 hours. If her father and grandfather finish the job, it will be finished within 8 hours. How long will it take Dika, her father, and her grandfather to complete the crops, if they work individually?

Figure 1. A non-routine problem given to the students.

Figure 1 is one of the non-routine problems compiled in the three-variable linear equation system material. The original problems are given in Indonesian with the complex situation [3]. It seems that this question is about the reciprocal proportionality, but the solution is using the three-variable linear equation system. In addition, reasoning that occurs in a problem solving is connecting the new material with the material that has been studied by students before [17]. In problems like figure 1, the new material is the three-variable linear equation system and the material that students have experienced before is the reciprocal proportionality. Besides fulfilling the criteria for non-routine questions, the problem in figure 1 also fulfills the criteria for the values of general education, mathematical values, and the values of mathematics education.

This study designs five non-routine problems. From the result, it is found that the five non-routine problems meet the criteria for the value of general and mathematics education, but not for the mathematics value. Values of mathematics values from each non-routine problem are presented in table 1. From table 1, it was found that the five non-routine problems had different mathematics values. Problems number 1 and 2 have the same mathematics values, as well as problems number 3 and 4. At number 1 and 2 have values of rationalism, objectivity, control, progress, and openness, but no mystery. Problems number 3 and 4 have the values of rationalism, control, progress, and openness, but do not have values of objectivity and mystery. Problem number 5 has values of progress, openness,

and mystery. The value of progress and openness are found in each problem. The value of objectism is only in problems number 1 and 2. The value of rationalism and control are found in problems number 1, 2, 3, and 4. The last, all of the values of the mathematics values are not found in one problem.

Table 1. Elements of mathematics values in non-routine problems.

Problems	Rationalism	Objectivity	Control	Progress	Openness	Mystery
1	√	√	√	√	√	-
2	√	√	√	√	√	-
3	√	-	√	√	√	-
4	√	-	√	√	√	-
5	-	-	-	√	√	√

Note : √ means presented.
- is not presented.

From this design, it is found that the value of general and mathematics education can appear on any non-routine problems, but not for mathematics value. Not only that but it is also found that the mystery value emerges along with the value of progress and openness. But, the mystery value does not appear together with the values of rationalism, objectivity, and control. Control values and the value of rationalism can be presented in the same problem [18]. This is because when the students do recheck the steps of solving problems, they can use rules or formulas to solve the problems.

4. Conclusion

The mathematical values that appeared students work were rationalism, objectivity, control, progress, openness and mystery.

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