The Profile Analysis of Problem-Solving Skills on Work and Energy Material Using "Multiple-Ways of Rosengrant"

V Vidyawati[1], P Sinaga[2], L Hasanah[3]
{vidyawati@upi.edu[1]}

Departemen Pendidikan Fisika, Universitas Pendidikan Indonesia, Indonesia[1, 3]
Departemen Pendidikan Ilmu Pengetahuan Alam, Universitas Pendidikan Indonesia, Indonesia[2]

Abstract. This research aims to determine the improvement of problem-solving skills and skill level in solving problems on the business and energy topic of high school students. The research method used is the quasi-experiment with a post-test control group pre-test design. The subject for this study amounted to 60 SMA grade X students at one of the schools in Bandung which was determined by purposive sampling. The instrument used is a matter of essay based on problems in everyday life. Measurement of problem-solving capability is a pre-test and post-test corresponding to the Multiple-ways of the Rosengrant indicator. Data analysis uses the percentage of average gain in normalization and interacting with hake criteria. After the study, there was an increase in problem-solving skills with moderate criteria, with an <g> N-gain normalization rate of 0.49. The results showed improved problem-solving skills at each level.

Keywords: Problem Solving Skills, Quasi-Experiment, Multiple-Ways of Rosengrant

1 Introduction

Physics is a part of natural science and is developed based on physical phenomena that happen in nature from a series of the scientific process. Many students already have a good understanding of physics' concepts and principles, but the ability to solve physics problems is still lacking [1]. Because of that, an effective learning strategy is still needed to be done by teachers [2]. One way to solve the physics problem is students must deeply understand the physics concepts. Students are also required to master various representations simultaneously.

Learning by using various forms of representation can facilitate students to explore more about physics concepts [3]. Using appropriate forms of representation about physics concepts that are taught will make students not only memorize it but also understand the concept as well [4]. To be able to learn physics effectively, students must understand the use of representations in explaining a physical concept and manage to translate representations of a concept from one form to another [5]. With the representation format, questions and concepts can be expressed in various ways, such as by using graphics, free body diagrams, and others. Having skills in using various representations and coordinating multi representations is very beneficial in learning physics, other than as a tool to understand concepts. Those skills even can facilitate students' problem-solving skills [6]. Based on the literature's study, research on multi-representation with the ability of student representation in solving problems has been done by Rosengrant, et. all, 2007b[7]. The research is focusing on the ability of students to solve problems using

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representations, the emergence of representations, and the quality of representations. The intended representation is free-body diagrams. The result of the study shows that free-body diagrams are beneficial if students make the free-body diagrams correctly. If students misuse the free body diagrams, they get a low score [7]. Kohl and Finkelstein concluded that student's success in solving physical problems was influenced by the format of representation of those physics problems [7],[8].

This article aims to gain an overview of learning strategies to improve student's problem-solving skills and to escalate student's ability to build a representation of physics problems in work and energy material. The model of system representation from Triadic Peirce is shown on **Figure 1**.

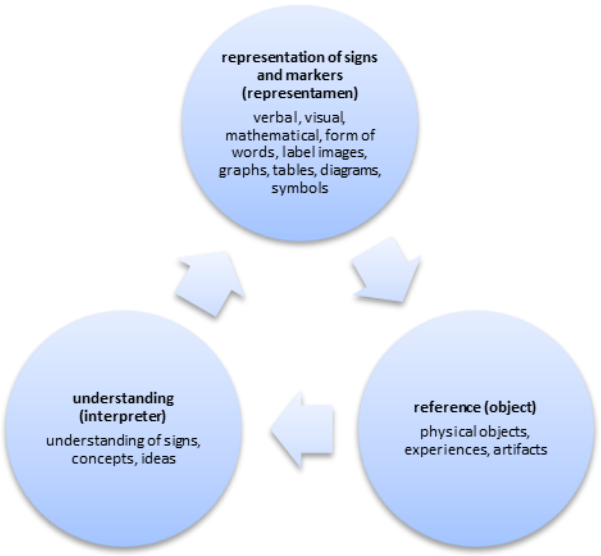

Fig. 1. The model of system representation from Triadic Peirce [9].

2 Experimental Method

The method used in this study was quasi-experiment by comparing the experimental class and the control class results[10]. The experimental class is a class of students who learn with the Rosengrant multi representation-based problem-solving strategy, while the control class learns with the Polya problem-solving strategy. Pre-test and post-test are done to both classes to see the development of students' problem-solving skills and the ability to build a representation. Based on the research purpose conducted, the research design used is the pretest-posttest of non-equivalent group design [11]. In this design, the study uses experimental groups and comparative groups that begin with an initial test (pre-test) given to both groups. After that, treatment is given to both groups. The research ends with a post-test given to both groups. The population in this study is all 10th-grade MIPA students in one of the Senior High School in West Bandung district in 2018/2019 school year. While the samples involved in this research are two classes of X MIPA which includes 60 students.

The sampling technique used is purposive sampling. Sample from the population conducted by considering the classes that received work and energy material in the high school's curriculum.

Problem-solving skill is measured by using the essay test as the instrument. The test is done to know students' success rate in learning on their problem-solving skills and building representation ability. The levels of problem-solving skills are determined by creating an assessment rubric adapted from Rossengrant. The levels consist of: Missing (very low/zero), Inadequate (less capable/low), Needs Some Improvement (need development/moderate) and Adequate (capable/good). Based on those levels or classification, students' problem-solving skills can be measured and classified.

Students' ability to build a free body diagram (FBD) representation is measured by using an essay test as the instrument. The levels of building free body diagram skill, show on Table 1. This test is done to know students' ability in analyzing and describing the free body diagrams of an object. Students' ability to draw free body diagrams is classified by using free-body diagrams skills rubric [7]. The rubric consists of four levels. Each level has the characteristics from the lowest level to the highest level. Multi-representation skill's assessment rubric show on Table 2

Table 1. The levels of building free body diagram skill.

No evidence of	Inadequate	Needs improvement	Adequate
0	1	2	3
No representation is depicted.	There is FBD depicted, but there are still some errors such as the existence of additional styles that are not included in the object system and the wrong vector directions of the force.	There is FBD depicted and no additional style includes in the object system. But there is an error in labelling the name of the force and the vector length from the force.	The depicted FBD is complete. There is no fault in labelling force's names, vector depictions, and force direction. By that, the depicted FBD matches the presented problem.

Table 2. Multi-representation skill's assessment rubric.

No.	**Scientific skills**	**Missing [score 0]**	**Inadequate [score 1]**	**Needs Some Improvement [score 2]**	**Adequate [score 3]**
1	Able to properly filter information from a representation.	No effort was made to sift through the information from the presented problem.	There are errors in filtering information, such as less precise in labeling amounts.	Some information is filtered correctly, but only partially. The numbers are only filtered with proper labeling but without a unit.	All important information is filtered appropriately and formed representation is visible.

No.	Scientific skills	Missing [score 0]	Inadequate [score 1]	Needs Some Improvement [score 2]	Adequate [score 3]
2.	Able to make representations from previous representations.	No effort was made to make a different representation.	There are attempts to make representations. But students still use incorrect information or inappropriate representations.	Representations are made without error, but no information such as naming and variables.	Representations are made using all information and do not contain large flaws.
3	Able to assess the consistency of different representations and modify them if needed.	No representation is made to assess the suitability.	One representation is made but there is no suitability between the representations made with the representation provided.	Representations are made according to each other but there is a slight discrepancy in the representation given. It can be a modification made in the representation.	All representations, both made and given, have compliance with each other.
4.	Able to use representations to solve problems.	No effort was made to answer the questions.	Giving wrong answers.	The answer is correct but representation is not used.	The answer is correct and multi representation is used. There are also some mathematical calculations.
Assessment rubric based on the representation that can be created by students					
5.	Free-Body Diagram (FBD)	No representation made.	FBD has been created, but there are still errors such as mislabelled or no labelling on force's vector. Vector length and vector direction are still wrong.	There is no fault on created FBD. But it is still a lack of label completeness on force's vector or vectors not drawn from a single point (position of objects are on the system).	There is no fault on created FBD and every force is labeled. So, it is easy to understand the forces that have been shown.
7.	Energy Flow Diagrams	No representation made.	The diagram that is made does not indicate flow/movement, The fault can be the vector motion is not created, and the	No error in creating motion vector diagrams, but there is still a deficiency in the form of a single point representing the position of the	The overall diagram is correct and clear. Description of the motion of an object on the path is made.

No.	Scientific skills	Missing [score 0]	Inadequate [score 1]	Needs Some Improvement [score 2]	Adequate [score 3]
			less precise of vector label.	object being or the difference in length of the vector when experiencing changes.	
8.	Chart	No representation made.	No value from a single graph is created, or a value created in wrong. The graph value interval representing on each axis is not continuous.	The created line graph corresponds to the conservation of values on the axis of the chart. But the formed graphics are less precise/not smooth.	The entire chart created between the two axes is correct and corresponds with the magnitude of the conservation of the value interval.
9.	Pictures	No representation is made.	Images are created, but not exhaustive because there is a deficiency in the physical label or misinformation.	The images of the majority of items are created, but there is still less precise label information on the image item.	The whole image contains all the correct and precise items.
10.	Mathematical	No representation is made.	Mathematical representations that do not have algebraic passages (directly include numbers), applying the wrong concept of algebraic.	There are no errors found in analysing, but the description of the problem solving is less complete. There is still a unit of algebra that is made less or less precise.	There is no fault in mathematical representation. It is written systematically.

3 Result and Discussion

Based on data findings and analysis, Rosengrant's problem-solving strategy can improve student's problem-solving skills with a normalized gain of 0.49 in the medium category. While the Polya problem-solving strategy can improve student problem-solving skills with a normalized gain of 0.15 in the low category. The comparison can be seen on **Figure 2**.

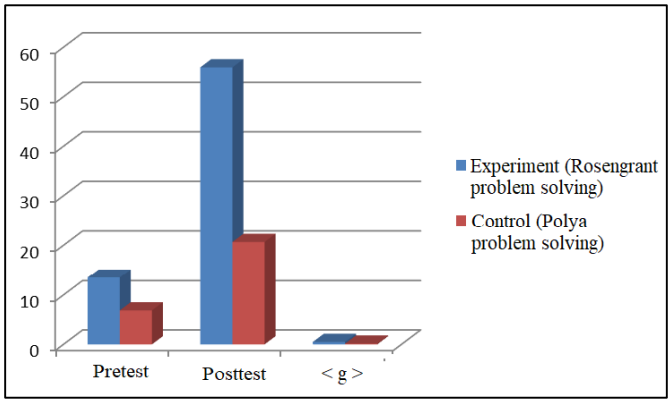

Fig. 2. The comparison of Rosengrant's problem-solving skill gain with Polya problem-solving skill gain.

Based on the Rosengrant framework of problem-solving skills, there are four stages of problem-solving capabilities: the ability to translate problems, simplify problems, depict free body diagrams, and write mathematical equations and its solutions. For each stage of ability, the accomplishment is analyzed based on the acquisition of pretest, posttest and N-gain scores. Based on the data, it is known that all the problem-solving stages are improving in both the Rosengrant problem-solving strategy class and the Polya problem-solving class. The result can be seen on **Figure 3**.

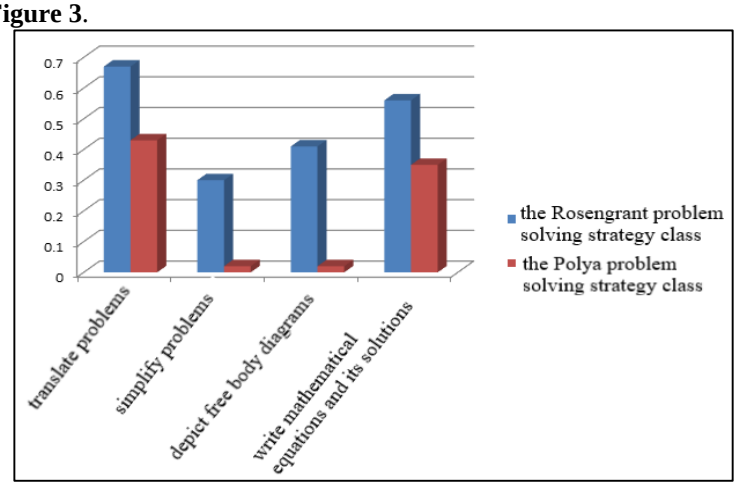

Fig. 3. The result of students' collaboration skill.

Students' ability to build physics representations is categorized by Multi-representation skill's assessment rubric by Rosengrant. The ability is measured in the form of percentages based on the number of students at each level. In the problem-solving strategy of Rosengrant class, the highest average percentage was at level 3 of 67.5%, next is Level 2 of 25.8%, Level 4 by 4.17% and level 1 by 2.5%. In the problem-solving strategy of Polya class, the highest average percentage of the ability to build physics representation is at 47.5%, next is Level 2 by 31.7%, at level 3 by 19.2% and at level 4 by 1.7%. The comparison can be seen on **Figure 4**.

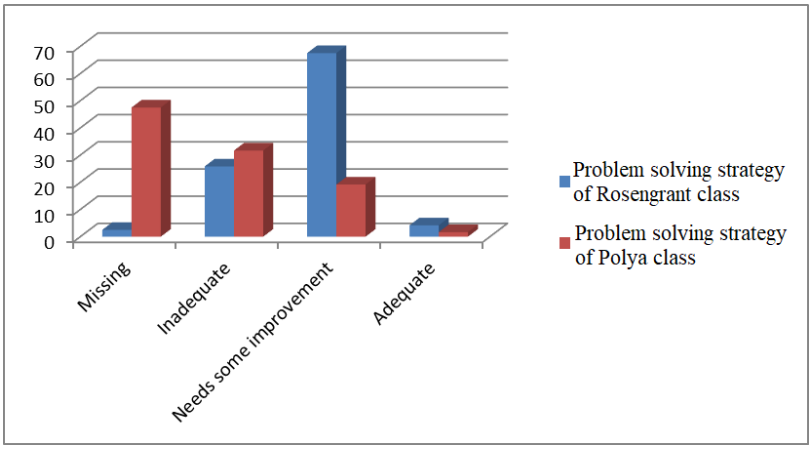

Fig. 4. Students' ability to build physics representation at each level in the problem-solving strategy of Rosengrant class and problem-solving strategy of Polya class.

Based on the analysis of both classes, the number of students' percentage at each level shows that students in problem-solving strategy with Rosengrant's multi representation approach class is better on building more complex representation than students in the problem-solving strategy with Polya class.

This happens because students from the experimentation class get to study problem-solving strategies with a multi representational approach that provides the ability to build representation. At the learning activity, students are given the appearance of pictures, videos, and demonstrations as a means of familiarizing students with identifying the key concept. After students have obtained the key concept, students are subsequently trained to create a new representation of the displayed image along with the verb instructions to create an image of physics. One of them is in the form of a free body diagram. So, the overview of internal representation is obtained which then becomes the resulting external representation. While in the class of problem-solving strategies with Polya, students do not acquire activities that practice the ability to build such representations.

4 Conclusion

Rosengrant's problem-solving learning strategy involves the active role of students in learning activities on describing the representations acquired and solve problems. So that they can be used in learning other materials. Implementing The Rosengrant problem-solving strategy needs to be applied by teachers consistently so that students are better trained in solving physical problems.

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