The development of physics learning materials using multimodal representation to improve the problem-solving skill of high school students based on Rosengrant stages

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Abstract. This study aims to determine the effect of the development of physics learning materials using multimodal representation to improve the problem-solving skills of high school students based on Rosengrant stages. The sample used in this study is 69 students from a high school in Bandung. The research sample was divided into 2 classes called the experimental class and the control class. Control class uses usual learning materials in the school while the experimental class using multimodal representation learning materials. The sampling technique in this study using class random sampling. The instrument for obtaining data on students' problem-solving abilities using essay test instruments on heat and temperature material which consists of 8 questions. The results of this study indicate that the development of physics learning materials using multimodal representation are able to improve students' problem-solving skill significantly based on Rosengrant stages.

1. Introduction
The process of developing student learning is the main focus of an education. There are many factors that influence the learning process, one of this factor is learning materials. Students learn about the attitudes and skills of the environment (the teacher and his friends) while the learning materials give knowledge by providing learning concepts that can be used in daily life.

Learning material is a unit of learning that contains information, discussion and evaluation in the learning process[1]. Information contained in learning materials in the form of knowledge that will develop students' insights. This knowledge is also explained systematically and logically[2]. This certainly will help students to achieve basic competencies in the learning process.

A good learning material has certain conditions, namely: the description of the concept must be true and clear, the order of the discussion is arranged inductively or deductively, the depth and breadth of the concept according to the level of student development, integrating verbal and visual representation (multimodal representation), sequence of usage modes its representation in accordance with the need so that the concept becomes more clear, can encourage readers to want to read more material in the learning materials, and use punctuation in accordance with the appropriate Indonesian grammar rules [3].
Learning materials used in the learning process should be able to help students understand concepts more clearly, especially in physics learning if they have met the requirements of good learning materials. Good learning materials and according to student needs will make the learning process become more interesting [4]. However, the reality in the school is that learning materials used by students are not suitable with their needs because physics learning materials contain concepts that are difficult to understand, do not contain phenomena in life, and do not train problem-solving abilities [5]. Therefore, it takes innovation and development of books carried out by the teacher so that physics learning materials can be obtained that suitable for student needs [6].

Physics lesson contains various abstract concepts so that students difficult to understand it. To overcome this difficulty, the object or concept of the lesson must be made more real for students [7]. The concepts of the lesson can be made into a representation form so the concept can be understood and clearer. The representation can be interpreted as something that describes or symbolizes objects and processes so that they become more real [8]. Abstract objects, for example, can be made in graphs, images, or charts form. This certainly will help students understand the subject matter and be able to apply the concept in their daily life.

The ability of students to construct their knowledge is different. Therefore, when a concept has been represented, it is not enough to use only one representation but must be in several representations form called multi representations [9]. Multi representation is a model that represents the same concept in several different forms. Multi representations on concepts can make in verbal, images, tables, graphs, diagrams, and mathematical equations form. Multi representation also applies to science subjects, especially physics because science cannot be completed if it is communicated to students only through verbal form but must be able to combine verbal and visual forms [10].

When describing a concept using multi representation, the forms of representations must be integrated with each other, which is called multimodal representation. The use of multimodal representation is expected to be able to help students improve their conceptual understanding of learning because this conceptual understanding is not only useful for improving students’ cognitive abilities but also helps students to understand their application in daily life.

Learning physics is very closely related to phenomena in daily life. When students feel the benefits of learning the concept, students will be interesting to find out more knowledge [11]. From the results of interviews with grade X students in a high schools in Bandung it is obtained that students expect a learning materials that not only full of physics concepts but also completed with examples of the application of the concepts in daily life so that when they face a problem, students can use the concepts learned to solve the error. Therefore, physics learning must be directed at problem-solving abilities because physics is not just memorization and calculation but also includes analysis of problem-solving in daily life.

The ability to analyze concepts to be able to apply in solving the problem itself requires practice in the form of structured stages. The stages of the problem-solving process used in this study are based on Rosengrant’s problem-solving stages. The stages are the ability to describe the problem, simplify the problem, describe the physical form, and describe the mathematical form [12]. These four stages can be used in various daily problem solving and calculation problems. These stages will be very supportive in training and familiarizing students to be able to solve problems using the correct concept of physics.

One of the advantages of using multimodal representation is that it can help students to improve problem-solving skills. When a problem is made in several integrated representations, the problem will be simpler and easier to find a solution. Joseph and Gayle stated that the use of multi representation methods in learning can improve students' problem-solving skill according to their different learning styles [13]. Nguyen also stated the same thing in his findings that some representations such as graphical representations and mathematical equations make the students difficult to understand the problem but it became easier if they use multi representation to solve problems in mechanics [14].
2. Research Method
The purpose of this study is to develop a learning material that uses multimodal representation to improve students' problem-solving skills so that the research method used is R and D (Research and Development). The book that will be developed is a physics learning materials on heat and temperature concept. The development of this learning materials was carried out using Borg and Gall stages, they are initial information gathering, planning, initial product development, initial trials, initial revisions, field trials, product revisions, field tests, final revisions, dissemination and implementation[14]. The research population used included all classes in one of the high schools in Bandung. The samples taken were 2 classes selected by class random technique and the number of samples was 69 students[15]. The subjects of this study divided into two classes and it called experimental class and control class. The experimental class is taught using multimodal representation learning materials and the control class is taught using learning materials commonly used by students in learning activities at school.

The process of implementing a multimodal representation learning materials that have been developed using quasi-experimental methods with a randomized control group pretest-posttest design. The research data was collected using a problem-solving ability test instrument. The instrument test consists of 8 essay questions. During the learning process, researchers use the same learning method, called the PQ4R method (Preview, Question. Read, Reflect, Recite, Review).

3. Results and discussion
The results of the acquisition of problem-solving skills at each stage of the tests conducted by researchers are presented in table 1 and table 2.

| Category                  | Number of Students and Their Score Of Each Stage | Pretest | Posttest |
|---------------------------|--------------------------------------------------|---------|----------|
|                           | S1      | S2      | S3      | S4      | S1    | S2    | S3    | S4    |
| Score 3 (Adequate)        | 0%      | 0%      | 0%      | 0%      | 67%   | 33%   | 21%   | 61%   |
| Score 2 (Need Improvement)| 70%     | 49%     | 33%     | 61%     | 33%   | 67%   | 79%   | 39%   |
| Score 1 (inadequate)      | 30%     | 51%     | 67%     | 39%     | 0%    | 0%    | 0%    | 0%    |
| Score 0 (No evidence)     | 0%      | 0%      | 0%      | 0%      | 0%    | 0%    | 0%    | 0%    |

| Table 1. Students’ problem solving of rosengrant stages in the experimental class |

Based on Table 1 and Table 2, data were obtained that in stage 1 of the pretest experimental class and control class, the level of problem-solving skill of students was still at Need Improvement category and Inadequate category. At the first stage of the pretest, there was not a single student who was able to reach Adequate category. These results indicate that students' conceptual understanding is still lacking and has not been able to describe the problems presented properly. In this case, the
process of guidance, training to habituation in describing the problems of a problem is needed by students. After students finish studying with physics learning materials using multimodal representation, the problem-solving ability test is again given to students and the results show 67% of students in the experimental class have reached Adequate category while the other 33% are at Need Improvement category. The results obtained in the control class are 5% of students have reached Adequate category, the other 92% are at Need Improvement category and 3% at Inadequate category. Increasing the ability to solve this phase 1 problem is in the experimental class. This shows that the use of multimodal representation learning materials is more successful in improving students’ problem-solving skills at the stage of understanding and describing problems compared to learning materials commonly used in schools. This increase is specifically due to the use of examples of problem-solving problems that clearly train the problem-solving skills at each stage.

At pretest stage 2, the quality of problem-solving abilities of the students in the control class and the experimental class is still at Need Improvement category. On the pretest at stage 2, there was not even one student who was able to reach Adequate category. The highest percentage is still at Inadequate category, in the experimental class at 51% and in the control class at 94%. These results indicate that students are still not able to simplify a problem that is well presented. The results of stage 1 show that students’ ability to describe the problem is at Inadequate category so that it is in line with the results in stage 2 which is also at Inadequate category. If students are not able to understand and describe the problem, of course, students will not be able to simplify the problem. To overcome this, understanding the concept of students must be improved and habituation in learning. Students’ problem-solving abilities were tested again in the form of posttest after students studied with physics learning materials using multimodal representations. The results of this test showed 33% of students in the experimental class were in the stage of Satisfaction and the other 67% in the Need Improvement category. The results in the control class amounted to 47% at Need Improvement category and the other 53% were at Inadequate category. These findings indicate that the highest increase was in the experimental class. This increase in results shows that the use of multimodal representation learning materials is more successful in improving students’ problem-solving skills at the stage of simplifying problems compared to students who use ordinary learning materials at school. This increase is mainly due to conceptual understanding and using examples of problem-solving at each stage clearly.

At pretest on stage 3 of control class and experimental class, the quality of students’ problem-solving skill are also at Need Improvement category and Inadequate category. The highest percentage was at Inadequate category about 67% in experimental class and 86% in the control class. This finding shows that students have not been able to make a physical picture of the problems given in the book. The third stage is considered by students as the most difficult problem-solving stage and this can be seen from the initial test results data where the acquisition of student results at Inadequate category is at this stage. This is caused by learning materials that are commonly used by students not clearly describing physical concepts so that the concepts become alien and cannot be imagined by students. Students in the experimental class then learn with physics learning materials that use multimodal representation and students in the learning control class with usual learning materials in school. The results problem-solving test obtained at the posttest showed that the students in the experimental class had reached Adequate category of about 21% and Need Improvement category about 79%. For the control class, the results obtained 53% for Need Improvement category and 47% in Inadequate category. From the results obtained, it can be seen that the highest increase was in the experimental class even though most of them were still at Need Improvement category. This increasing result shows that multimodal representation learning materials in physics are more successful to improve students' problem-solving skill at the physical description stage of the problem when compared to students who learn to use ordinary learning materials. This increase is due to the use caused by the presentation of examples of problems and problem-solving exercises that clearly train problem-solving skills at each stage.

The fourth stage of the problem-solving ability gets the best results. In stage 4, the percentage of 39% is in Inadequate category in experimental class and 47% in the control class. This finding shows
that students are better in the fourth stage compared to other stages even though the results still need to be improved. From the data, it can be concluded that students still need to practice how to solve the problem using mathematical abilities. In this case, students need guidance on using a better math formula and habituation in learning. After students in experimental class learning with physics learning materials using multimodal representations and students in the learning control class with ordinary learning materials, the test results on the posttest showed 61% of students in the experimental class had reached Adequate category while the other 39% were at Need Improvement category. The results obtained in the control class about 19% at Adequate category and 81% at Need Improvement category. From these findings, it can be seen that the highest increase was in the experimental class even though most of them were still at Need Improvement category. The magnitude of the increase in these results shows that the use of multimodal representation learning materials is more successful in improving students' problem-solving abilities at the physical picture stage of the problem compared to students who use ordinary learning materials.

In physics learning materials using multimodal representations developed by researchers, formulas or indirect equations are presented but the presentation begins with an analysis of how to obtain the formulation and the meaning for what the formula is used. The presentation of the formula in this way makes students better understand the formula not only as a mathematical tool but also understand its physical meaning in solving problems.

To find out the difference in increasing the problem-solving ability of each stage, in this study the average N-gain data difference test will be carried out. The test results are shown in Table 3.

**Table 3. Normality test, homogeneity, and data difference test N-gain problem-solving ability for each stage**

| Data Test | Class | N   | Sig*  | Conclusion                  |
|-----------|-------|-----|-------|-----------------------------|
| Normality | Experiment | 33  | 0.420 | Data is distributed normally |
|           | Control   | 36  | 0.153 |                             |
| Homogeneity| Experiment | 33  | 0.000 | Both data come from unequal variances |
|           | Control   | 36  |       |                             |
| t-test    | Experiment | 33  | 0.018 | There are differences in abilities |
|           | Control   | 36  |       |                             |

Based on Table 3, the findings show that the data increases the problem-solving ability of each stage with a significance of 0.420 in the experimental class and 0.153 in the control class. The significance value is greater than the value of $\alpha$ (0.05). It is concluded that the data are normally distributed. The N-gain data is normally distributed so that the homogeneity test is then carried out and a significant finding of 0.000 is obtained. This significant value is smaller than the value of $\alpha$ (0.000>0.05). It is concluded that the two data are from different variances. To test the difference in the average N-gain the t test is done and a significance value of 0.018 is obtained. This significant value is smaller than the value of $\alpha$ (0.018 <0.05). It is concluded that the development of learning materials using multimodal representation improving problem-solving ability significantly of each Rosengrant’s stage compared to the application of the usual learning materials in school.

4. Conclusion
Data from research that has been done shows that learning process with physics learning materials using multimodal representations can improve students’ problem-solving skills significantly at each stage based on Rosengrant framework.
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