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Efforts in Increasing Physics Learning Outcomes: Comparing Two Different Methods

Fitriani Kadir[1)*], Imam Permana[2)]

[1)]Physics Education Study Program, Muslim University of Maros, Maros, 90511, Indonesia
[2)]Physics Education Study Program, State Islamic University of Alauddin Makassar, Makassar, 92113, Indonesia

Corresponding author: fktria85@umma.ac.id

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Abstract – *The teaching method used by the teacher is closely related to the results obtained by students during learning. This study aims to analyze whether there are differences in students' learning outcomes of physics taught by problem-solving and probing prompting methods and which method is more effective in improving physics learning outcomes. This type of research is experimental, with a post-test only control group design. The population in this study were all students of class X MAN 2 Model Makassar, which consisted of six classes with a total of 252 students, while the sample was taken using a random class technique. Class X MIA 2 and class X MIA 3 were selected as samples, with a total of 42 students in each class. The results showed that in the cognitive domain, the physics learning outcomes average score of students who were taught using the problem-solving method was 77.08; meanwhile, that of the students taught by the probing prompting method was 81.00. In the psychomotor domain, the learning outcomes average score obtained by the class taught by problem-solving method and probing prompting method were almost equal, that was 98.32 and 98.28, respectively. Finally, in the affective domain, the students' learning outcomes after using the problem-solving method was 84.20, and that after using the probing prompting method was 83.90. Therefore, it can be concluded that there are differences in physics learning outcomes between students who are taught using problem-solving and probing prompting methods. The probing prompting method is more effective in increasing students' learning outcomes in the cognitive domain, while the problem-solving method is more effective in developing students' psychomotor and affective domains.*

Keywords: *learning methods; physics learning outcomes; probing prompting; problem-solving*

I. INTRODUCTION

Physics is one of the subjects in the science family that develops inductive and deductive analytical thinking skills in solving problems related to surrounding natural events (Marisda, 2016; Bancong & Putra, 2015). The importance of the role of physics demands that the learning process be carried out well (Marisda et al., 2020). Applying learning methods that do not involve students will result in students' not concentrating in understanding the learning material (Kodi, 2021). Many factors influence the success of implementing learning in the classroom, including factors from the students themselves, learning facilities, and methods used by teachers (Emda, 2018; Muchlis et al., 2018). Therefore, along with the development of science and technology, teachers are required to create and develop learning methods that can improve the quality of learning.

From the literature review, it is found that there are two learning methods that have a significant effect on learning outcomes, namely the problem-solving method (Kadir et al., 2020; Nasar & Kurniati, 2020; Kahar et al., 2018) and probing prompting method (Kodi, 2021; Oktaviyanti et al., 2018; Ismatulloh et al., 2020). Learning activities with problem-solving methods refer to scientific methods such as searching for data, processing and drawing conclusions (Udin & Hikmah, 2014; Bancong & Putra, 2015). Problem-solving skills are important to be taught to students. Learning experts assume that problem-solving abilities can be formed from the disciplines being taught (Hadi & Radiyatul, 2014). One way to be able to assess problem-solving in physics education is to provide questions in the form of procedural analysis. Procedural task analysis can be used to group tasks into several components, then organize to find relationships, to the stage of drawing the right final conclusion (Mustofa & Rusdiana, 2016).

On the other hand, the probing prompting method is a learning method that presents a series of questions guided by the teacher in exploring students' ideas so that they can jump-start the thinking process that is able to connect students' knowledge and experiences with the new knowledge learned (Syiami, 2015). The probing-prompting learning method is suitable for use as a physics learning strategy because it directly affects students' thinking activities and creativity in solving problems given by the lecturer (Hathcock et al., 2015). Table 1 presents the different steps of the problem-solving method and probing prompting method.

Table 1. The difference in steps between the problem-solving method and probing prompting method

Stage	Problem-solving method	Probing prompting method
I	Student orientation to the problem	Facing students with new situations
II	Organizing students to learn	Provide opportunities for students
III	Guiding individual and group investigations	Asking question
IV	Develop and present the work	Formulate answers
V	Analyze and evaluate the problem-solving process	Ask one of the students to answer the question

Several previous studies have shown that problem-solving methods can improve physics learning outcomes. For example, Kadir et al. (2020) revealed that students' physics learning outcomes on elasticity material taught using the problem-solving method were higher than those taught using the lecture method. Nasar and Kurniati (2020) also found that students who were taught using the problem-solving model had a significant increase in physics learning outcomes. Problem-solving methods encourage interaction for students during the learning process so that learning can run effectively and efficiently and students are able to understand the material being taught (Kahar et al., 2018; Said et al., 2021). Previous studies have also revealed that the probing prompting method can improves students' responsibility and the understanding of physics concepts (Oktaviyanti et al., 2018; Ismatulloh et al., 2020). In addition, the probing prompting learning method can also improve students' mathematical abilities needed in learning physics (Dominikus et al., 2020).

However, previous studies have not clearly described which method is more effective in improving physics learning outcomes, especially at the high school level. For this reason, in this study, the comparison of the effects of the two methods on physics learning outcomes will be known. In this study, the learning outcomes that will be measured are the final scores obtained by students after being given the application of problem-solving methods and probing prompting methods. The research questions are (1) are there any differences in students' physics learning outcomes after being taught by problem-solving and probing prompting methods? Which method is more effective in improving physics learning outcomes?

II. METHODS

The type of research used was true experimental research (Sugiyono, 2018), with a posttest-only control group design model. Based on the design above, there were two classes used, in which one class was taught by using the problem-solving method and the other class was taught by using probing prompting method. At the end of the lesson, both classes were given a test to determine students' learning outcomes (post-test).

Class 1	X1	O1
Class 2	X2	O2

Figure 1. The design of this study

The research was conducted at MAN 2 Model Makassar, in the even semester of 2021/2022. The independent variables in this study were problem-solving method and probing prompting method, while the dependent variable was students' learning outcomes. The population in this study were all students of class X MAN 2 Makassar Model which consisted of six classes with the total students were 252 people. The sample in this study was determined through a simple random sampling technique with the assumption that the population was homogeneous. Based on the results of the draw, it was obtained that class X MIA 2 and class X MIA 3, each consisting of 42 students, were the samples of the study.

The instrument used in this study was a test of students' learning outcomes in physics. This test is given after teaching and learning activities. The test of students' learning outcomes in physics is carried out in the form of a multiple-choice written test. Each item has only one correct answer choice. If students answer correctly for the C1 domain, they get a score of 1, C2 gets a score of 2, C3 gets a score of 3, C4 gets a score of 4, C5 gets a score of 5, and C6 gets a score of 6. To determine the abilities of the psychomotor and affective domains of students, an observation sheet was used. The observation sheet is a measuring instrument in the form of a checklist filled out by the researcher/observer during the learning process, containing an assessment rubric regarding attitudes and skills.

Data processing was carried out by employing descriptive statistical analysis and inferential statistical analysis. The descriptive statistical analysis aims to provide an overview of the characteristics of the achievement of students' learning outcomes for classes with a problem-solving method and probing prompting method. Data processing with descriptive statistical analysis was the average score, highest score, lowest score, standard deviation, completeness of learning outcomes, and categorization of learning outcomes from each class. There were five predicates used to determine the level of physics learning outcomes categories, namely: very low, low, medium, high, and very high.

On the other hand, the inferential statistical analysis aims to test the proposed research hypothesis. If the data obtained are not normally distributed, then hypothesis testing cannot be done by parametric statistical analysis but is analyzed non-parametrically (Sugiyono, 2018). Before testing the hypothesis, a prerequisite analysis test was carried out consisting of a normality test and a homogeneity test. The normality test used the chi-square test formula at a significant level = 0.05. The hypothesis in this study was that there is a significant difference in physics learning outcomes between students who are taught using problem-solving methods and students who are taught using methods of probing prompting. Figure 2 shows the procedure of this research.

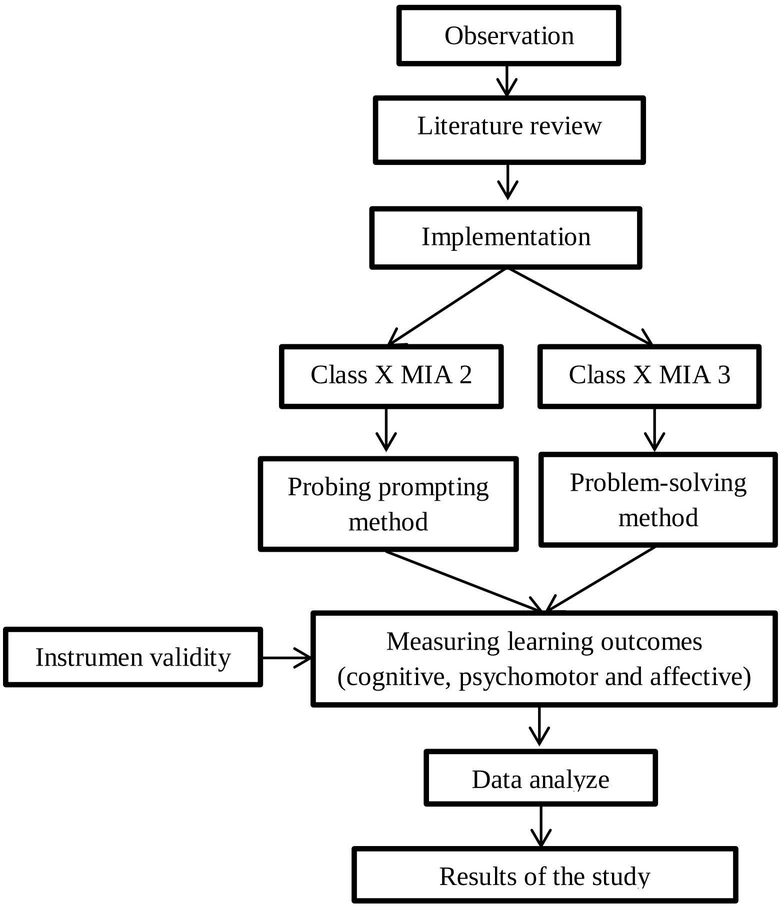

Figure 2. The flowchart of this study

III. RESULTS AND DISCUSSION

The results of the descriptive analysis showed that there were differences in learning outcomes between students who were taught using the problem-solving method and the probing prompting method. As we can see in Table 2, the average score of physics learning outcomes for students who are taught using problem-solving methods is 77.08, with a median of 78 and a standard deviation of 2.25. Meanwhile, in the class taught by the probing prompting method, the average score obtained by students was 81, with a median of 80, and a standard deviation of 6.70. Table 2 shows the comparison of students' learning outcomes of physics taught by the problem-solving method and the probing prompting method.

Table 2. Recapitulation of physics learning outcomes

No	Items	Problem-solving method	Probing prompting method
1	Mean	77.08	81.00
2	Median	78.00	80.00
3	Standard deviation	8.49	6.70
4	Variance	72.08	44.89
5	Maximum score	96.00	94.00
6	Minimum score	55.00	65.00

Furthermore, data on the frequency distribution of physics learning outcomes using problem-solving and probing prompting methods can be described in the form of a histogram, as shown in Figure 3. As can be seen, in the class that was taught using the problem-solving method, there were 20 students (48%) achieved very high category scores, and 22 people (52%) obtained in the high category scores. There were no students' scores in the medium, low, and very low categories. Meanwhile, in the class taught using the probing prompting method, it is known that there were 14 students' scores (33%) in the very high category, 25 students' scores (60%) in the high category, and 3 students' scores (7%) in the medium category. None of the students' scores were categorized as low and very low categories.

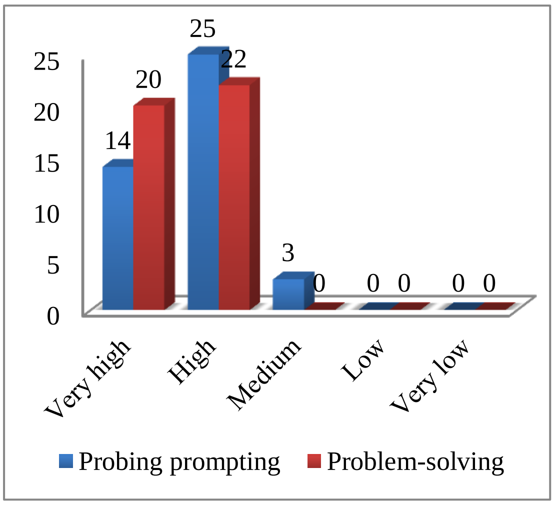

Figure 3. The average score of physics learning outcomes

The curriculum used in MAN 2 Model Makassar is the 2013 curriculum, which assesses not only students' cognitive aspects but also students' affective and psychomotor aspects. The psychomotor assessment consists of two skill assessments, namely performance skills and portfolio skills. While the affective or attitude assessment is divided into 8 assessment indicators for each meeting, namely spiritual assessment, honesty, discipline, responsibility, tolerance, mutual cooperation, courtesy and self-confidence.

The results of the final score of skill competence (psychomotor) showed that the average score of the students who were taught using problem-solving method was 98.32, while that of the students taught by the probing prompting method was 98.28. This shows that both methods are effective in improving students' psychomotor competence. In other categories, the results of the affective competency scores obtained by students who were taught by problem-solving methods was 84.20 (very good). Meanwhile, the students who were taught by using the probing prompting method showed that the affective score obtained was 83.90 (very good). This shows that both methods are effective in improving students' affective competence.

The normality test was carried out to determine whether the data on physics learning outcomes obtained were normally distributed and became the requirement to determine what types of statistics were used in further analysis. The results of the calculation of the normality test for the students taught using problem-solving method was X^2_{count} = 10.60; and it is known that X^2_{count} = 10.60 < X^2_{table} = 11,07. Thus, it can be concluded that the score of physics learning outcomes taught using problem-solving methods was normally distributed. Meanwhile, the results of the calculation of the normality test for students who were taught using the probing prompting method was X^2_{count} =10.17; and it is known that X^2_{count} =10.17 < X^2_{table} = 11.07. Thus, it can be concluded that the score of physics learning outcomes taught using probing prompting methods was also normally distributed.

In addition, the homogeneity test was intended to show that two or more groups of sample data come from populations that have the same variance. The testing of the homogeneity of students' physics learning outcomes using problem-solving methods and probing prompting methods was carried out using the F test statistical formula. The results showed that F_{count} = 1.60 < F_{table} = 1.69. Thus, it can be concluded that the data variance of the two groups was homogeneous.

After calculating the prerequisite test, hypothesis testing was conducted. Hypothesis testing was carried out to prove the proposed hypotheses. Based on the results of t-test calculation: t_{count} > t_{table} (2.20 > 1.68), then H0 is rejected and H1 is accepted. This means that there were differences in physics learning outcomes between students who were taught using problem-solving and probing prompting methods. The results of this inferential statistical analysis show that the learning outcomes of students who were taught using the method of probing prompting were higher than those of students who were taught using problem-solving methods. Overall data analysis shows that the class applying the probing prompting method has better physics learning outcomes than the class using the problem-solving method.

The striking difference between students' physics learning outcomes in class X MIA 2 and class X MIA 3 was caused by the application of two different learning methods. In the probing prompting method, after the teacher had finished carrying out apperception, students were invited into a learning situation with new material. Students were faced with several media images, videos, experimental demonstrations or problems related to the material. Then the teacher asked questions, the nature of which was to explore the knowledge of students so that students could understand the problem implicitly through the images that had been presented (probing). At this stage, students were given the opportunity to think about answering questions from the teacher. After the students understood the problems posed by the teacher, it was continued with investigation activities, where the teacher gave a series of questions, either posed directly by the teacher or stated in the students' worksheet. It aims to link students' prior knowledge with the material to be studied.

For example, the teacher provides case examples with questions about the learning process. "*If you observe the condition of water of a lake and a river, why is lake water calmer than river water?"* students answered, "*because the lake water does not flow while the river water flows"*. The teacher can ask again, "*why does river water flow?"* Some students answered *because there is pressure*. Students thought for some time and then answered each question given. And in the process of thinking, students asked themselves, "*is it only the river that has pressure while the lake at rest has no pressure"?* So even though the lake water was calm, there was still pressure there, and the teacher could help students solve problems through questions or concepts and linked to formulas. Students could find out the relationship between the depth of a liquid and pressure, where the deeper the position of an object from the surface, the greater the pressure.

Furthermore, the students were asked to form small groups and later discussed the students' worksheet. At the next stage, students were given the opportunity to answer the questions in the student worksheet. In this activity, the teacher only became a facilitator if students found obstacles or difficulties in working on the student worksheet. After the students finished working on the student worksheet, they presented the results of the discussion in front of the class. In order to test the students' understanding, after the discussion and presentation activities, the teacher, again, asked several questions. The questions asked were questions that we're exploring and directing students' understanding. At this stage, the teacher appointed students randomly, aiming that all students could actively participate in the learning process.

Unlike the case with learning to apply problem-solving methods, the problem was presented first before teaching the solution to the students. Practice here took the form of giving questions and experiments. As apperception, the teacher asked students and gave examples in everyday life related to the material. Then students were given opportunities to express opinions, asked them to write down problem formulations and hypotheses from applications or examples given to build initial knowledge, and when students began to explore the question, the teacher asked students to sit based on the group friends that have been determined. The teacher distributed students' worksheets to each group and asked students to take out their textbooks. Students joined groups of friends and started the practicum. The teacher did not interfere when students tried to solve problems (student-centered). Here the teacher only acted as a facilitator and motivator. All problems must be solved by the students themselves.

During the data collection, the students' attitudes and skills were assessed and written on observation sheets. After data collection, students presented the results of their group work, and the other groups paid attention and asked questions. However, in the teaching and learning process, many obstacles occur. Students should be accompanied during the process of solving problems in student worksheets because sometimes there are students who do not understand the use of experimental tools.

Problem-solving requires things with clear evidence, so that there is no ambiguity in solving problems, including perspectives or opinions on the problem. Thus, a clear solution is needed, including things in the reality of life. Therefore, with this experiment, the existing theory can be tested to prove it. Thus, students will better understand the concept, not only memorizing the sound of the law, formula, or understanding.

The results of data analysis show that both learning methods have an effect on learning outcomes. This is in line with the research of Tampubolon and Sitindaon (2013) and Prihatiningtyas and Sholihah (2020), which states that the application of problem-solving in learning can lead students to get involved actively in learning. In addition, several studies have found that the probing prompting method can streamline a tense learning atmosphere because students must always be responsive to the questions the teacher give, and probing prompting varies greatly so that students can understand the subject very easily (Putri et al., 2016; Setiawati et al, 2019). This means that applying those two methods can help to reach the expected learning objectives. In sum, the differences in physics learning outcomes between students who are taught by the method of probing prompting and students who are taught by the method of problem-solving are due to differences in treatment in the learning steps and the process of delivering the material. The method of probing prompting emphasizes more and is closely related to the questions, while the problem-solving method relies on practice or practicum.

IV. CONCLUSION AND SUGGESTION

Based on the results of the analysis and discussion, it can be concluded that there are differences in physics learning outcomes between students who are taught using problem-solving and probing prompting methods. The results of learning physics in the cognitive domain of students who are taught by using the probing prompting method are higher than by using the problem-solving method. In addition, although both methods were effective in improving students' psychomotor and affective competencies, problem-solving methods proved to be more effective than probing prompting.

In relation to the results obtained in this study, the authors propose several suggestions. Firstly, teachers can apply problem solving and probing prompting methods as alternative learning methods in improving physics learning outcomes. Secondly, to improve students' physics learning outcomes, especially in the cognitive aspect, the probing prompting method is more effective than the problem-solving method. On the other hand, if the teacher wants to improve students' physics learning outcomes, especially in the psychomotor and affective aspects, the problem-solving method is more effective than the probing prompting method. Finally, for other researchers who are interested in conducting this kind of research, they should better understand the steps of the problem-solving method and the probing prompting method and data collection in a wider scope.

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