



Application of Problem-Solving Method to Improve Learning Outcomes of Class X Students of SMAN 1 Tuntang Semarang District on Environmental Pollution Material

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Abstract. Student learning outcomes are the abilities which produced by students after carrying out learning activities. Through the implementation of problem-solving method, it is hoped to boost active learning and problem-solving communication. This study aims to improve student learning outcomes on environmental pollution material and to find out problem-solving method implementation for Class X at SMAN 1 Tuntang. The study involved 27 students of class X. It used the Classroom Action Research (CAR) method with 2 cycles which have 4 stages: planning, action, observation, and reflection. The instruments included tests, observation sheets, interview sheets and documentation. Data analysis techniques use the completeness formula of Student Learning Outcomes (SLO), N-gain, and problem-solving method implementation. The results showed that student learning outcomes had increased as seen in the pre-test average score in cycle I of 68.89, rising to 85.93 in the post-test, achieving a SLO of 96%. In Cycle II, the pre-test average was 65.19 and post-test average value of 85.93 has succeeded in achieving a SLO of 100%. The implementation of learning using the problem-solving method in the first cycle was 97% (very good) and the second cycle was 100% (very good). N-gain was 0.56 in the first cycle and 0.60 in the second, both considered moderate. The conclusion is that using problem solving techniques to learn about environmental pollution for class X SMAN 1 Tuntang through laboratory exercises the sub chapter on water pollution can enhance student learning outcomes. This method of teaching is rated as being of very high quality.

Keywords: Classroom action research, Environmental pollution, Learning outcome, Problem-solving method

1 Introduction

Education is an effort to develop human resources. This is a way for humans to move towards a better direction in order to increase human resources in keeping up with technological developments and advances. The aim of education is to develop the qualities of an individual, as an activity that is aware of the goal. Practically the interrelated processes in each type and level of education must be mutually sustainable with an integral education system [1]. One thing that can be seen is the change in the curriculum in Indonesia which was carried out as a form of anticipation of developments and needs of the 21st century in order to perfect the character and competency-based curriculum [2]. Minister of Education and Culture Regulation number 20 of 2016 contains 3 dimensions, namely attitudes, knowledge and skills [3]. Education has an important role in preparing quality human resources who can face future challenges and be able to compete in the development of science and technology. Education in Indonesia is currently continuing to develop, many reforms are being carried out to improve the quality and quantity of learning [4].

PISA (2018) shows that learning outcomes in Indonesia are ranked 63rd out of 70 countries. This shows that student learning outcomes are low [5]. Student learning outcomes are the abilities produced by students after carrying out learning activities. The learning process is an interaction between teachers and students in achieving the expected learning goals. Teachers must have strategies in the teaching and learning process so that students can learn effectively and efficiently [6]. According to [7] the problems found in class are the lack of students' understanding of biological concepts which causes students to get bored easily and not be interested in biology lessons. Apart from that, teachers teach monotonously and the methods used are less varied and only stick to textbooks.

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Based on the results of the interview, the biology teacher at SMA Negeri 1 Tuntang stated that there were still some students who did not pay attention when the teacher was explaining and only took notes on the material, which caused some students to get an average learning outcome score of 68.89, including below the Student Learning Outcomes (SLO).

In biology learning, the method usually used is the conventional method (lecture) which does not provide opportunities for students to be active in learning so that students tend to remain silent and only listen to explanations from the teacher and conventional learning does not facilitate students to collaborate with each other [7]. The selection of strategies, approaches, methods and methods has an important role in the teaching and learning process. However, in practice, not every method is appropriate to the material being taught. The learning methods used in schools are still teacher-oriented (teacher-centered) so that the learning process in schools is not optimal [8].

An effort to improve student learning outcomes, efforts are needed to improve learning strategies, namely methods that can make it easier for students to increase their understanding of learning material, so that students can achieve maximum learning outcomes. One method that can be used is a problem-solving based learning method [9]. The problem-solving method is a problem based learning method, namely learning that is "learner centered" oriented and centered on solving a problem by students through group work [10]. The problem-solving method is a way of solving problems by stimulating and providing understanding so that students can pay attention, think and examine a problem. Using this method can train students to solve problems skillfully and optimally as well as train students' critical thinking skills [11]. Problem solving methods have a great influence on improving student learning outcomes in the process of understanding, searching for information, and finding solutions [12]. According to [13] in the problem -solving method there are four steps that must be taken, namely understanding the problem, devising a plan, carrying out the plan, and looking back.

Basically, students are required to be involved in processes such as presenting an answer to a problem in a test about understanding students' concepts related to environmental pollution material. This material is also contextual and there are quite a lot of problems that can be related to the understanding process. In this way, students can come up with ideas related to environmental pollution so that students are able to answer the problems given [14]. The reality in the field of biology learning requires an approach that is related to everyday life. Learning that starts from real problems will be more meaningful for students, so that students' understanding and learning outcomes in biology increase [15].

An effort to improve the quality of learning processes and outcomes is through Classroom Action Research (CAR) [16]. CAR begins by identifying a problem that occurs in class, then solving it using planned actions. CAR helps teachers solve problems that occur in the learning process so that the results obtained are better and the objectives of the learning can be achieved well [17]. CAR is research that applies action in the classroom and is reflective by using rules in accordance with research methodology carried out in several cycles to be able to improve or increase learning practices so that an increase in understanding or predetermined targets is obtained [18]. CAR has stages in its cycle consisting of planning, implementation, observation and reflection [17].

Based on the description above, CAR was carried out with the aim of improving student learning outcomes on environmental pollution material, especially water pollution, which was carried out by simulating laboratory activities by applying problem-solving method in class X at SMAN 1 Tuntang.

2 Method

This research is Classroom Action Research (CAR). This research was carried out at SMAN 1 Tuntang in the second semester of the 2022/2023 academic year, October 2022 – May 2023. The research subjects were 27 students at class X at SMAN 1 Tuntang. The number of meetings used was four meetings in the sub-chapter of water pollution and solutions/efforts to overcome water pollution by applying problem-solving methods through simple laboratory activities. The steps in the research are as follows:

2.1 Cycle I

Planning

1. Researchers carry out classroom observations to see learning activities in class

2. The researcher held a discussion with the biology teacher to find out the problems that occurred in class X
3. Researchers provide solutions to overcome problems that occur in class
4. Researchers and teachers hold discussions regarding the material that will be used for research
5. Develop a flow of Learning Objectives (ATP) for class X
6. Develop a teaching module about water pollution using problem-solving method
7. Prepare Student Worksheets (PSW) related to water pollution material and prepare learning resources and tools that will be used in learning
8. Develop evaluation tools such as pre-test and post-test sheets to determine student learning outcomes in learning and observation sheets to see the implementation of learning using problem-solving method
9. Validate research devices and instruments.

Implementation

1. Teacher provides motivation and apperception regarding water pollution that will be taught
2. Teacher conveys the learning objectives
3. Teacher carries out the students at class X the stages of learning by doing the problem-solving method

a. Understanding the Problem

Teacher gives a pre-test to students as an initial stimulus in entering the material for 15 minutes. The teacher presents a picture of rubbish scattered on the surface of the water, then the teacher asks the question "what do you think when you see this picture?" "What does this have to do with living things?" Then the teacher shows one of the pictures related to biological parameters, namely the results of the *E. coli* bacteria test on well water samples. The teacher asks the students again, "What other parameters can be used to see whether the water is polluted or not?" Students answer questions from the teacher. Then the teacher conveys the learning objectives and explains the learning activities that will be carried out.

b. Devising a plan

Teacher divides the students into 5 groups where each group consists of 5-6 students. Group division is carried out by counting from 1 to 5. The teacher directs them to divide the tasks in doing group assignments so that the assignments can be completed on time. The teacher gives student worksheets to each group as practical material and group discussions. The teacher conveys the procedures for working on the PSW given to students. Groups 1 and 2 (sample C), groups 3 and 4 (sample B), and Group 5 (sample A). Teachers also facilitate students in finding information from various sources, including books, modules and the internet.

c. Carrying out

Teacher guides students in carrying out practical work, processing various information and discussing in finding solutions to the problems presented. Furthermore, the teacher also directs students to exchange ideas between students in groups. The teacher controls all activities of each group. After the laboratory activities, students began to have discussions to answer the questions on the PSW. The teacher takes the conditions of the class so that the class remains conducive. The teacher monitors and controls all groups so that all groups can finish on time.

d. Looking back

Teacher asks each group to present the results of the work they have done. Presentation activities are carried out in front of the class. Where the presentations begin in sequence starting from groups 1 to 5. Each group advances and the other groups are ready to provide input or questions to the group making the presentation. The teacher guides and directs the presentation. After completing the presentation, the teacher provides confirmation of answers via PowerPoint. The teacher provides reinforcement in the form of material/topics that have been summarized through PPT. Then the teacher gives students the opportunity to ask the teacher questions regarding material they have not yet understood. After presenting the material, the teacher and students make conclusions regarding the lessons they have learned and how they relate to everyday life. Then the teacher gives a post-test for students to do for 15 minutes. After conducting the post-test, the teacher provides motivation and reflection to the students and then close the lesson with greetings.

Observation

Observations are carried out based on the sheet or form of implementation using the problem-solving method which is filled in by the observer. Observation sheets are used to evaluate and assess the implementation of learning

using problem-solving method. The score of student learning outcomes were assessed through multiple choice tests carried out at the beginning and end of the cycle, and the resulting data on learning outcomes becomes quantitative data on improving student learning outcomes.

Reflection

In the reflection stage the researcher analyzes the results of the observations that have been made. The results of observations, researchers will find out student learning outcomes. If 100% of students reach the SLO, then the cycle is stopped. However, if 100% of students have not reached the SLO, then CAR continues to the next cycle. After the implementation of learning using the problem-solving model in cycle I, generally the implementation of laboratory activities was in accordance with the teaching modules that had been prepared, but there were still obstacles that needed to be corrected, namely:

- 1) Cooperation and division of tasks between each group member is not optimal
- 2) Each group is required to provide responses and questions to the group making the presentation
- 3) Instructions from teachers need to be clearer
- 4) Practical work and discussion time can be managed well according to the distribution of time.

2.2 Cycle II

Planning

Base on the 4th problem was occurred in cycle I, the cycle II will be started by staging as follow:

1. Prepare a teaching module regarding material on solutions/efforts to handle water pollution using problem-solving method
2. Prepare Student Worksheets (PSW) related to material on solutions/efforts to handle water pollution and prepare learning resources and tools that will be used in learning
3. Develop evaluation tools such as pre-test and post-test sheets to determine student learning outcomes in learning and observation sheets to see the implementation of learning using problem-solving method.

Implementation

1. Teacher provides motivation and apperception regarding water pollution that will be taught
2. Teacher conveys the learning objectives
3. Teacher carries out the stages in the problem-solving method
 - a. Understanding the problem

Teacher gives a pretest to students as an initial stimulus in entering the material for 15 minutes. The teacher presents a picture of rubbish scattered on the surface of the water, then the teacher asks the question "can cloudy water samples become clear again?" "What steps or solutions can we take?" "Does anyone have an opinion?" Students answer questions from the teacher. Then the teacher conveys the learning objectives and explains the learning activities that will be carried out.

- b. Devising a plan

Teacher divides the students into 5 groups where each group consists of 4-5 students. Group division is carried out by counting from 1 to 5. The teacher directs them to divide the tasks in doing group assignments so that the assignments can be completed on time. The teacher gives PSW to each group as practical material and group discussion. The teacher conveys the procedures for working on the PSW given to students. Each group makes a simple filtering tool from materials that have been brought by each group. Teachers also facilitate students in finding information from various sources, including books, modules and the internet.

- c. Carrying out

Teacher guides students in carrying out practicums, processing various information and discussing in finding solutions to the problems presented. Furthermore, the teacher also directs students to exchange ideas between students in groups. The teacher controls all activities of each group. After the practicum activities, students began to have discussions to answer the questions on the PSW. The teacher takes the conditions of the class so

that the class remains conducive. The teacher monitors and controls all groups so that all groups can finish on time.

d. Looking back

The teacher asks each group to present the results of the work they have done. Presentation activities are carried out in front of the class. Where the presentations begin in sequence starting from groups 1 to 5. Each group advances and the other groups are ready to provide input or questions to the group making the presentation. The teacher guides and directs the presentation. After completing the presentation, the teacher provides confirmation of answers via Power Point. The teacher provides reinforcement in the form of material/topics that have been summarized through PPT. Then the teacher gives students the opportunity to ask the teacher questions regarding material they have not yet understood. After presenting the material, the teacher and students make conclusions regarding the lessons they have learned and how they relate to everyday life.

Then the teacher gives a post-test for students to do for 15 minutes. After conducting the post - test the teacher provides motivation and reflection to the students and then closes the lesson with greetings.

Observation

Observations/observations are carried out based on the observation sheet of learning implementation using the problem-solving method which is filled in by the observer. Observation sheets are used to evaluate and assess the implementation of learning using problem solving methods as mention in Table 1.

Table 1. Implementation of the problem-solving model in cycle II

No.	Sintax	Observer	
		I	II
1	Understanding the problem
2	Devising a plan
3	Carrying out
4	Looking back
		Total	
		Percentage	
		Criteria	

Student learning or the cognitive outcomes are assessed through multiple choice tests carried out at the beginning and end of the cycle, and the results of the learning outcome value data become quantitative data on improving student learning outcomes.

Reflection

Researchers analyzed students' cognitive learning outcomes in cycle II. If 100% of students reach the SLO, then the cycle is stopped. However, if 100% of students have not reached the SLO, then CAR continues to the next cycle.

Data collection techniques consist of interviews, observations and tests. Interviews were conducted with Biology teachers to find out the learning process at SMAN 1 Tuntang. Observations were carried out to determine the implementation of learning using problem solving methods. The test is used to determine students' cognitive learning outcomes before and after learning through simple laboratory activities on water pollution material and solutions/efforts to handle water pollution. The test used is multiple choice consisting of 10 questions. Data analysis is used to measure students' cognitive learning outcomes through percentage of completion and descriptive analysis. Students are said to be complete if they reach the SLO or Minimum Completeness Criteria which is 75. Analysis of pre-test and post-test improvement through measuring the Normalized Gain (N-Gain) Score obtained using Hake's (1999) formula and criteria, then implementing learning using the method problem-solving through Guttman scale formulas and criteria (Table 2).

$$N\text{-gain} = \frac{\text{post test score} - \text{pre test score}}{\text{ideal score} - \text{pre test score}}$$

Table 2. N-gain criteria

Percentage	Criteria
$N\text{-gain} > 70$	High
$30 \leq N\text{-gain} \leq 70$	Moderate
$N\text{-gain} < 30$	Low

3. Results And Discussion

3.1 Results

3.1.1 Student Cognitive Learning Outcomes

Based on the results of the research carried out during the two cycles, the following data were obtained in Figure 1 to 3.

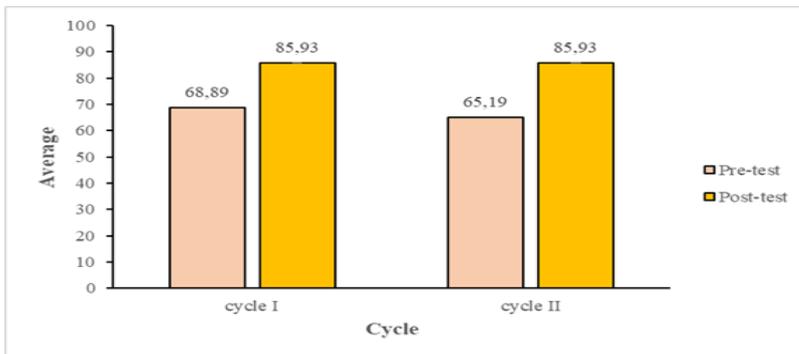


Figure 1. Average pre-test and post-test values for cycles I and II

Fig.1 shows the average value of student learning outcomes in cycles I and II. The increase in student learning outcomes can be seen in the average pre-test score in cycle I of 68.89 and the average post-test score of 85.93. In cycle II the average pre-test score in cycle I was 65.19 and the average post-test score was 85.93.

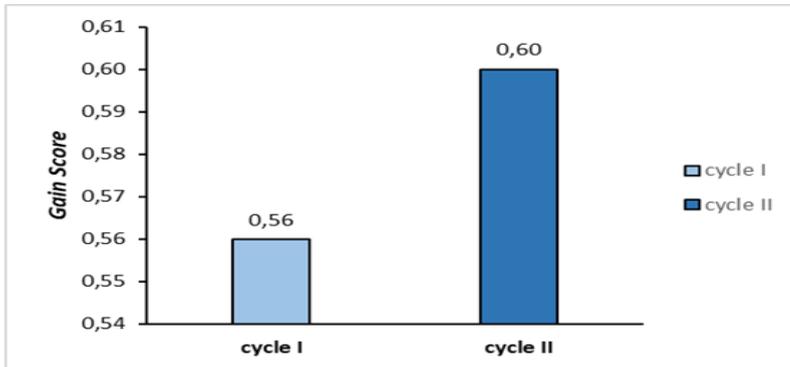


Figure 2. Average gain score in cycles I and II

Figure 2 shows the average gain score in cycles I and II. The average gain score in cycle I was 0.56, which is included in the medium category. The average gain score in cycle II was 0.60, which is in the medium category.

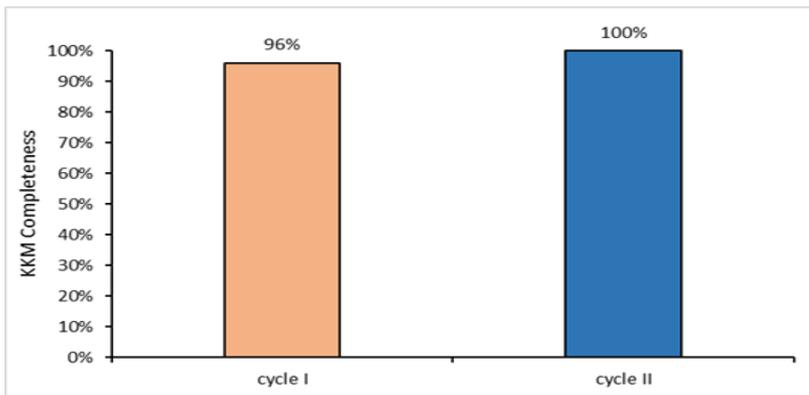


Figure 3. Percentage of students who achieve the KKM score

Figure 3 shows that the percentage of students who achieve the SLO score of 75 has increased in each cycle. In cycle I, SLO achievement reached 96%, then in cycle II it increased to 100%.

3.1.2 Implementation of Learning Using the Problem-Solving Method

Based on observations of the application of problem-solving methods in each cycle, the following results were obtained in Figure 4.

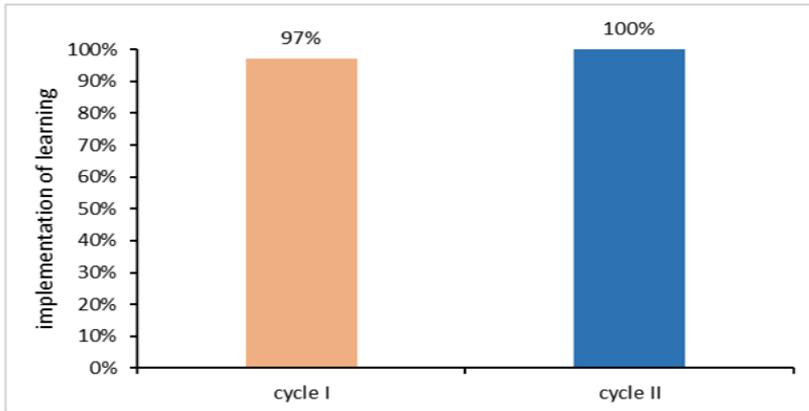


Figure 4. Implementation of Learning Using the Problem-Solving Method

Figure 4 shows an increase in the implementation of learning using the problem-solving method with a value in cycle I of 97% to 100% in cycle II.

3.2. Discussion

3.2.1 Improving the Learning Outcomes of Class X SMAN 1 Tuntang Students on Environmental Pollution Material by Applying the Problem-Solving Method

Based on Figures 1, 2, and 3, it is known that the problem-solving method can improve the learning outcomes of class X students at SMAN 1 Tuntang. In cycle I with environmental pollution material, student learning outcomes were obtained with a pre-test average of 68.89 and a post-test average of 85.93 with a SLO achievement of 96%. Cycle II with material on solutions/efforts to handle water pollution obtained a pre-test average of 65.19 and a post-test average of 85.93 with a SLO achievement of 100%. The average gain score in cycle I was 0.56, which is included in the medium category. The average gain score in cycle II was 0.60, which is in the medium category. Even though cycles I and II are included in the medium category, it can be said that the implementation of the learning process in cycle II is better than cycle I. Through this research it can be seen that the application of the problem-solving method can improve student learning outcomes because the problem-solving method invites students to play a role. active in the learning process so that students gain direct experience in solving problems through a given problem which will then produce good learning outcomes.

Based on the results of observations from cycle I with water pollution material, at the understanding the problem stage there were still several obstacles or shortcomings because some students did not pay attention and listen to the teacher when conveying the learning objectives so that the students did not understand them. This is because students are not yet accustomed to using problem solving methods with simple laboratory activities in the classroom. Apart from that, the pictures displayed by the teacher related to water pollution did not make students understand the concepts that would be studied in cycle I. Cycle II with material on solutions/efforts to deal with water pollution, the stage of understanding the problem (understanding the problem) showed a good response. By providing real facts around students, students begin to understand the objectives of learning. This is supported by the statement of [19] that if learning is explained based on real life it will make students understand a concept better, and through

experiments student learning outcomes can increase because this encourages students to understand a concept, objects and concepts.

The devising a plan stage in cycle I with water pollution material, group division made students less comfortable in their groups causing students not to discuss with their group friends and disturbed other groups. This is because the groups formed by the teacher have the same level of ability so students choose to discuss with friends who are more comfortable and know the material. Cycle II with material on solutions/efforts to deal with water pollution at the devising a plan stage, group divisions are in accordance with students' level of ability so that students can have group discussions comfortably. In student discussion activities, teachers must pay attention to group division based on heterogeneous student abilities so that students with high abilities can help students with medium and low abilities [20].

The stage of implementing the plan (carrying out the plan) in cycle I with material on water pollution, students carry out a simple practicum related to water pollution. In the practical activity the teacher asks students to measure and observe the temperature, DO, color and odor of polluted and unpolluted water samples. However, when students made observations, students did not read the observation steps well and there were some students who did not help their group friends so that the observation time was more than the specified time limit. In cycle II, at the stage of implementing the plan (carrying out the plan) with material on solutions/efforts to handle water pollution, students have read the experimental steps well so that the experimental time is within the given time limit. In this stage, students are asked to experiment with making a simple filtering tool. Meaningful learning for students is by conducting experiments that will instill deeper student memories regarding the material being taught so that student learning outcomes increase [21].

In the looking back stage in cycle I with water pollution material, some students were actively involved in presenting the results of their observations, but there were also some students who were not actively involved when presenting in front of the class so that these students experienced difficulties when the teacher asked about the results of their observations. The teacher also repeats and provides confirmation of answers so that students understand the material being presented. In cycle II, at the looking back stage with material on solutions/efforts to handle water pollution, students were able to actively discuss making a simple filtering tool. Students have also been able to draw conclusions from experiments that have been carried out well. This is in accordance with the opinion of [12], that the problem-solving method has a big influence on improving student learning outcomes in the process of understanding, searching for information and finding solutions.

According to [11], the problem-solving method is a way of solving problems by providing stimulus and understanding to students so that students can pay attention, think and examine a problem they find. By using the problem-solving method students can skillfully and optimally solve problems and train students' critical thinking skills. In general, students whose learning outcomes are good and optimal are students who are active in learning activities. According to Darsono (2001) in [22], student activity in the learning process is one of the factors that greatly influences student learning outcomes. The higher the student activity, the higher the learning outcomes obtained.

3.2.2 Implementation of Learning Using the Problem-Solving Method

Based on Figure 4, it shows that there is an increase in the percentage of learning implementation using the problem-solving method. Cycle I obtained a percentage of 97% in the very good category, and cycle II obtained a percentage of 100% in the very good category. The results show that in cycle I all planning actions were not implemented. Cycle I on water pollution material still experiences problems in its implementation by both teachers and students. In practice, teachers are still not optimal in carrying out monitoring in the practicum process. There are several problems, including that there are still many students who are not serious about the learning process (playing around) and joking around, there are still many who only rely on friends to work on their PSW, and the only students who are classified as smart students play an active role. Apart from that, the problem-solving model is not often used so many students are indifferent to learning. In the process of presenting discussion results, there are still students who are not confident or do not want to make a presentation in front of the class.

Therefore, in subsequent teaching and learning activities teachers must motivate and encourage students to play an active role in group discussions. Obstacles in cycle I could be caused by teachers and students not being familiar with problem solving methods through simple laboratory activities. Observing the learning process in cycle II on the

material on solutions/efforts to handle water pollution, students have started to play an active role in groups and learning is progressing better compared to cycle I. In this cycle students are very enthusiastic in carrying out the simple laboratory work and holding discussions. By dividing time appropriately and efficiently, it makes it easier for teachers to carry out monitoring, teachers to help and guide students who have difficulties, and teachers have more firm in giving sanctions to students when class conditions are not conducive so that learning outcomes in cycle II can improve. In cycle II the learning process was better because students were actively involved in the problem-solving process. According to [23] teachers are facilitators and guides for students. Teachers have the role of providing services to make it easier for students in the learning process, as well as teachers guiding students in discovering the various potential so that students can develop well.

4 Conclusion

The application of the problem-solving method for class X of SMAN 1 Tuntang on environmental pollution material can improve student learning outcomes with an average learning outcome score in cycle I of 68.89 to 85.93 with a SLO of 96% and cycle II of 65.19 to 85.93 with a SLO of 100%. The implementation of learning through simple laboratory work with the problem-solving method for class X students of SMAN 1 Tuntang on environmental pollution material is effective to apply, with an average N-gain score in cycle I of 0.56 with a moderate category, and in cycle II of 0.60 with a moderate category.

Disclosure of Interests. The authors hereby declare that there are no conflicts of interest, financial or otherwise, that could have influenced the research, analysis, or conclusions presented in this manuscript. There is no competition and all contributions have been made in a spirit of collaboration and academic integrity.

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