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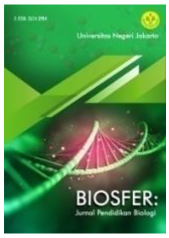


# Effect of problem-based learning model on biodiversity problem-solving skills

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**A B S T R A C T**

Problem-solving skill is a way or strategy to achieve goals following good and correct procedures. One of the learning models that can be applied to improve problem-solving skills is a learning model of Problem-Based Learning. The purpose of this research was to determine the effect of the problem-based learning model on student's problem-solving skills of biodiversity. This research was conducted at SMAN 89 Jakarta in August-September 2019. The method used was a quasi-experiment. The research sample was 66 students of class X MIA with a simple random sampling technique, the instrument used was pretest and posttest in the form of a description question. Instrument of problem-solving skills was tested for validity and reliability. The result of the validity test showed that there were 15 valid items out of 18 items. The reliability test showed that the r-value was 0,901 and included in very high criteria. The effectiveness test of the PBL model with normalized gain calculated score of 0,72 or included in the category of fairly effective. The research result showed that the problem-based learning model influenced students' problem-solving skills of biodiversity.



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## INTRODUCTION

The significant effect of the rapid development of information technology in the globalization era on the education world is unavoidable. The change will bring humans to a tighter global competition era; therefore, quality human resources, especially those with high-order thinking skills are required (Listiani, 2018). The 2013 Curriculum states that students are demanded to acquire high-order thinking skills (HOTS). One of the HOTS is problem-solving skills. Students, especially senior high school (SMA) students, need to possess the skills since it could help them to make accurate, careful, systematic, and logical decisions that consider various perspectives (Sari, Budijanto, dan Amiruddin, 2017).

The problem-based learning (PBL) model is a learning model that uses real-world problems as a context for students to learn critical thinking methods and problem-solving skills and to obtain knowledge and important concepts from a subject (Sudarman, 2007). Problems in the PBL are designed to demand students to obtain important knowledge, master problem solving, and acquire independent learning strategies and team participation skills. Solving problems requires a thinking process beyond memorizing and relaying the information back. The skills must connect possessed knowledge and experiences to think critically and creatively to determine decisions and solve problems in new situations (Sigit, et. al., 2017). Learning using the PBL model provides an opportunity for students to improve their scientific work skills (Destalia, Suratno, & Aprilya, 2014).

Students could use facts and problems provided in the characteristics of biodiversity content to optimize their scientific process and works (Muhlisin, et al., 2020; Astuti, Nurhayati, Ristanto, & Rusdi, 2019). In the biodiversity concepts, students could study various organisms and their relationship with the environment. It will be abstract for students to study the diversity of living things through pictures or in a lecture method. With the PBL model, students play more active roles in studying the subject and they could explain, analyze, and maximize their problem-solving skills. The PBL model supports the success of learning achievement; the stronger the students remember what they learn the more meaningful their learning (Sutriyani, 2019). Biodiversity threats could occur in the air, water, and soil. The high threats to biodiversity cause damage and a decrease in the quality and quantity of diversity of organisms. Humans play vital roles in the preservation of environmental potentials. Therefore, they need to be equipped to preserve the environment and address the biodiversity problems through environmental education. Based on the above description, a learning innovation is required by applying the PBL model to students' problem-solving skills in biodiversity content.

## METHODS

### Research Design

The research used a quasi-experiment of pretest-posttest control group design, which is a design that conducts pretest before treatment is applied and posttest after the treatment by randomly selecting control groups and experimental groups. The research design can be seen in Table 1.

**Table 1.**
Research Design of Pretest-Posttest Control Group Design

| Pretest | Treatment | Posttest |
|---|---|---|
| $O_1$ | X | $O_2$ |
| $O_3$ | C | $O_4$ |

Note:
$O_1$-$O_3$ : Initial skill test (*pretest*) of student's problem solving
$O_2$-$O_4$ : Final skill test (*posttest*) of student's problem solving

X : Learning in experimental class using PBL model
C : Learning in control class using Direct Learning model

## Research Population and Sample

The sample used in the research was selected using simple random sampling. Of the four classes of XMIA, two were selected, Class X MIA 1 as the experimental class and Class X MIA 2 as the control class. The sampling of 36 students for each class was conducted using simple random sampling. The data collection technique employed pretest and posttest for problem-solving skills and observation sheet instrument for the PBL model implementation.

## Instrument

The problem-solving instruments referred to Facione (2007), namely the six aspects of problem-solving skills that consist of (1) Identify (find a problem). When someone can describe a problem, he/she will know the real situation based on facts found; (2) Define (find the main cause of a problem). Problem-solving skills require skills of identifying and analyzing the cause of a problem; (3) Enumerate (generate several alternative solutions). This stage will produce more than one solutions to be used to solve a problem; (4) Analyze (analyze alternative solutions). Once various alternative solutions are derived, the best solution will be selected to solve the problem; (5*)* List (develop an action plan). An action plan is conducted to find out the effectiveness of solutions selected, and (6) Self-Correct (recheck the appropriate solutions). After the creation of the action plan, the selected solution is applied to solve the problem. The research instrument used included a written test in the form of an essay test that consisted of 18 question items with the highest score for each item was 4 and the lowest was 1. The validity test used the Pearson Product Moment formula. The test result suggested that of the 18 question items tested to 35 students, 15 questions were valid. The instrument reliability was calculated using Cronbach's Alpha formula. The reliability test result derived an r-value of 0.901 and was included in very high criteria. The research instrument was an observation sheet, which is a note that describes students' activity levels in the learning process. The observation was carried out by observing the teacher and student activities during the learning process by implementing the PBL model.

## Procedure

In the preparation stage, samples were determined for the experimental class and control class. The research instruments were created in the form of a problem-solving skill test that was previously tested for its validity and reliability. The syllabus, lesson plan, and student worksheets were prepared prior to the research. The implementation stage included a pretest for students in the experimental class and control class to find out the initial condition of their problem-solving skills on biodiversity content. The PBL model was applied in the experimental class. The posttest questions given to the experimental class and control class aimed to identify the results of students' problem-solving skill levels to learn the differences between both classes. In the data processing stage, the pretest and posttest scores of the experimental class and control class were analyzed using gain scores. The data analysis test consisted of a normality test using the Kolmogorov-Smirnov test, a homogeneity test using F-test, and hypothesis testing using a t-test statistical analysis. Finally, conclusions were drawn after the analysis.

## Data Analysis Technique

The normality test employed the Kolmogorov-Smirnov test and the data homogeneity test used the Fisher test (F-test) at a significance level of 0.05. The pretest and posttest data used the independent t-test at a significance level of 0.05 using SPSS version 23. The t-test of the pretest aimed to find out the equality in the experimental class and control class. The t-test for posttest was conducted to identify the after-treatment effect. The hypothesis testing employed statistical analysis of unpaired t-test at a significance level of 0.05 with the SPSS version 23. The normalized gain test was used to measure the difference between the pretest and posttest in the experimental class and control class.

## RESULTS & DISCUSSION

The results of the biodiversity problem-solving skill test in the form of pretest and posttest on 66 students in the experimental class and control class are presented in Table 2.

**Table 2.**
Problem-solving Skills Scores in Experimental Class and Control Class

| Data | Experimental Class | | Control Class | |
|---|---|---|---|---|
| | **Pretest** | **Posttest** | **Pretest** | **Posttest** |
| Maximum score | 66.67 | 100.00 | 58.33 | 93.33 |
| Minimum score | 31.67 | 71.67 | 30.00 | 63.33 |
| Average | 46.77 | 85.45 | 44.85 | 78.99 |
| Standard Deviation | 8.81 | 8.11 | 8.50 | 8.59 |
| **Normalized Gain (%)** | **72.50** | | **61.80** | |

In Table 2, the average pretest and posttest scores of the experimental class were higher than the control class. The score of minimum completion criteria (MCC) of SMA Negeri 89 Jakarta for Biology subject is 75. Based on the MCC score, the result of the problem-solving skill test on biodiversity content is shown in Table 3.

**Table 3.**
Results of Problem-solving Skill Test

| MCC | Experimental Class | | Control Class | | Description |
|---|---|---|---|---|---|
| | **Pretest** | **Posttest** | **Pretest** | **Posttest** | |
| < 75 | 100% | 6 % | 97% | 36% | Uncompleted |
| ≥ 75 | 0% | 94% | 3% | 64% | Completed |

Based on Table 3, both experimental class and control class experienced an increase in pretest and posttest scores. The experimental class had higher completeness than the control class. The average scores based on the problem-solving skill aspects' pretest and posttest scores in both classes are illustrated in Figure 1.

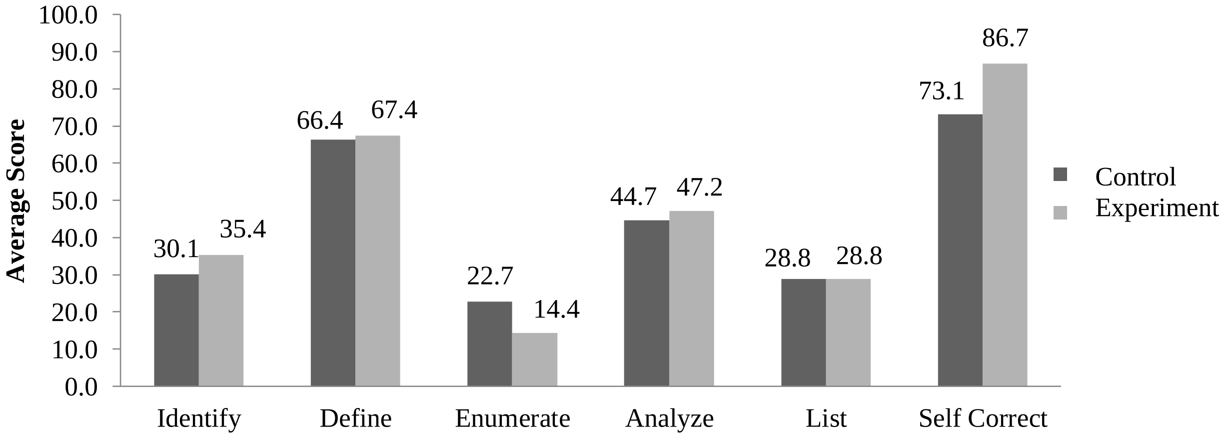


Figure 1. Average Score based on Problem-solving Skill Aspect Pretest

Figure 1 indicates that the average score based on the pretest of problem-solving skill aspects in the experimental class was higher on the identify, define, analyze, and self-correct aspects, whereas the control class had a higher score on the numerate aspect. The average scores based on the posttest of the problem-solving skill aspects are illustrated in Figure 2.

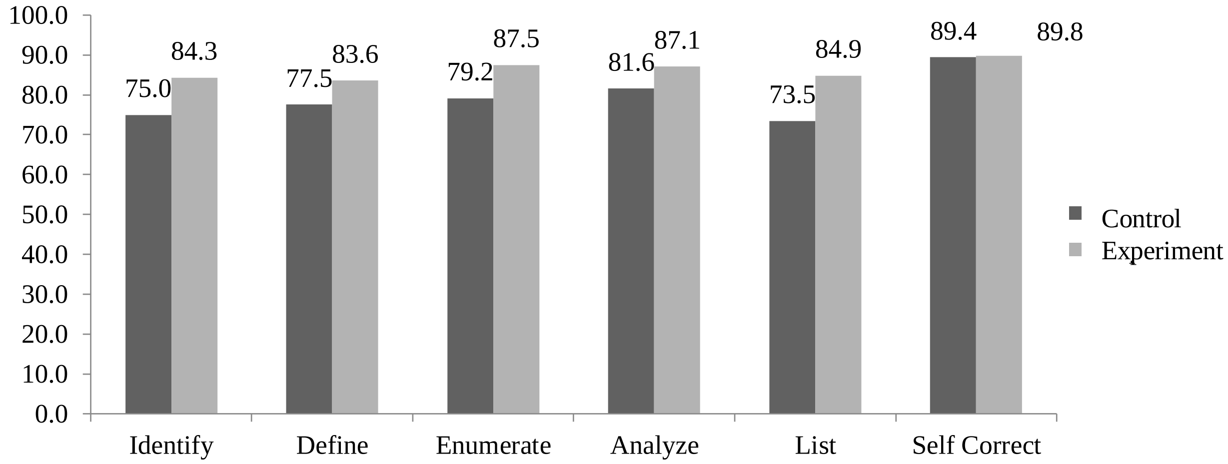


Figure 2. Average Score based on Problem-solving Skill Aspect Posttest

Figure 2 indicates that the average score based on the posttest of the problem-solving skill aspects in the experimental class was higher on all aspects than the control class. Observation on activities conducted by the teacher during the learning process used observation sheet of learning implementation. The percentages of the learning implementation by the teacher in the experimental class and control class are presented in Table 4.

**Table 4.**
Percentage of Learning Implementation by Teachers and Students

| | **Meeting 1** | | **Meeting 2** | |
|---|---|---|---|---|
| **Content** | Concept of Biodiversity, Flora Fauna, & Tropical Forests of Indonesia | | Utilization, Threats & Preservation of Biodiversity in Indonesia | |
| **Class** | Experiment | Control | Experiment | Control |
| **%** | 94% | 85% | 92% | 83% |

**Data Analysis**

The prerequisite tests included normality test using Kolmogorov-Smirnov test and homogeneity test using F-test at $\alpha = 0.05$. The tests used SPSS version 23. Data is normally distributed if the significance value is more than $\alpha$. The normality test results can be seen in Table 5.

**Table 5.**
Normality Test.

| **Class** | **Test Result** | **Sig.** | **A** | **Description** |
|---|---|---|---|---|
| Experiment | Pretest | 0.129 | 0.05 | Normal |
| | Posttest | 0.064 | 0.05 | Normal |
| Control | Pretest | 0.169 | 0.05 | Normal |
| | Posttest | 0.137 | 0.05 | Normal |

Regarding the homogeneity test, data is homogeneous if the significance value is more than α. The homogeneity test results are presented in Table 6.

**Table 6.**
Homogeneity Test

| Class | Test Result | Sig. | A | Description |
|---|---|---|---|---|
| Experiment | Pretest | 0.961 | 0.05 | Homogeneous |
| | Posttest | 0.412 | 0.05 | Homogeneous |
| Kontrol | Pretest | 0.961 | 0.05 | Homogeneous |
| | Posttest | 0.412 | 0.05 | Homogeneous |

Based on the calculation criteria, the $H_0$ was accepted at α = 0.05 meaning that the data of the test score of the students' problem-solving skills in both classes were homogeneous. The t-test used an independent t-test of pretest data to find out the equality in both classes, whereas the t-test for posttest was utilized to identify the effect of the PBL model on the problem-solving skills on biodiversity roblems. The independent t-test used SPSS version 23 with criteria of rejecting $H_0$ if there is an effect of PBL model on biodiversity problem-solving skills with a significance value of less than α. The results of the independent t-test on the pretest data of the biodiversity problem-solving skills are presented in Table 7.

**Table 7.**
Independent t-test of Problem Solving Skill Pretest

| Group | N | Mean | SD | Sig. | α | Description |
|---|---|---|---|---|---|---|
| Experiment | 33 | 46.77 | 8.81 | 0.087 | 0.05 | Sig. > 0.05 |
| Control | 33 | 44.85 | 8.50 | 0.087 | 0.05 | Sig. > 0.05 |

The t-test calculation results of the pretest data indicate that ρ was more than α with a significance value of 0.087 or more than 0.05; therefore, $H_0$ was accepted. It means that there were no differences in the average of biodiversity problem-solving skills or it can be assumed that both classes were equal. Regarding the independent t-test results of the posttest data are shown in Table 8.

**Table 8.**
Posttest Independent t-test of Problem-solving skills

| Group | N | Mean | SD | Sig. | α | Description |
|---|---|---|---|---|---|---|
| Experiment | 33 | 85.45 | 8.11 | 0.000 | 0.05 | Sig. < 0.05 |
| Control | 33 | 78.99 | 8.59 | 0.000 | 0.05 | Sig. < 0.05 |

The hypothesis testing used the independent t-test on the gain score data to identify the effect of the PBL model on biodiversity problem-solving skills. The test results are indicated in Table 9.

**Table 9.**
Independent t-test on Gain Score of Problem-solving skills.

| Group | N | ‾Mean | SD | Sig. | α | Description |
|---|---|---|---|---|---|---|
| Experiment | 33 | 38.78 | 8.48 | 0.000 | 0.05 | Sig. < 0.05 |
| Control | 33 | 34.15 | 8.61 | 0.000 | 0.05 | Sig. < 0.05 |

Table 9 indicates that the significance values of the independent t-test on the gain score of problem-solving skills were 0.000< 0.05; thus, rejecting $H_0$ at α = 0.05. It can be interpreted that there was a difference in the average of students' problem-solving skills taught using the

PBL model. Therefore, the PBL model had an effect on the problem-solving skills of students in Class X on the biodiversity subject. The normalized gain test was performed to find out the difference between the pretest and posttest in the experimental class and control class and the effectiveness level of the learning model. The normalized gain test results are showed in Table 10.

**Table 10.**
Normalized Gain Test

| Class | Gain score | Normalized Gain | Description | Normalized Gain (%) | Description |
|---|---|---|---|---|---|
| Experiment | 38.78 | 0.72 | Medium | 72.50 | Fairly effective |
| Control | 34.15 | 0.61 | Medium | 61.80 | Fairly effective |

The calculation results derived a gain score and normalized gain of the experimental class that was higher than the control class, whereas the effectiveness level in the experimental class taught using the PBL model was fairly effective compared to the control class taught using conventional learning.

The results of the hypothesis testing on the gain score using the independent t-test suggest that the PBL model affected biodiversity problem-solving skills. Based on the average gain score, the experimental class had a higher result than the control class. This was due to the fairly effective implementation of the PBL model compared to conventional learning. This is supported by Afcariano's (2008) statement that the implementation of problem-based learning improves problem-solving skills in Biology subject.

The average score based on the problem-solving skill aspect on the pretest data indicates that the experimental class had a higher score on the aspect of identify, define, analyze, and self-correct, whereas the control class had a higher score on the enumerate aspect. This was related to the biodiversity subject that has been taught in junior high school; thus, most students still remember the content. Based on the cognitive theory, students who have prior understanding will kept the understanding in their memories (Siregar& Nara, 2010). Problems in learning include the lack of opportunity for students to develop their problem-solving skills. Learning mostly orients toward teacher activity to deliver content without activities that stimulate students to think to solve a problem. Consequently, teachers less develop learning and tend to be improvised (Ramdhani, 2014)

The average score based on the problem-solving skill in the posttest indicates that the experimental class had higher results on all aspects than the control class. Referring to the minimum completeness criteria, the average pretest result in both classes was below 75 with the highest score on the self-correct aspect; therefore, it can be assumed that both classes had equal concept understanding skills. On the contrary, the posttest of the experimental class met all the minimum completeness criteria, whereas, in the control class, the list aspect was still below the KKM. This was due to the average posttest score on problem-solving skills in the experimental class that was higher than the control class. This proves that the PBL affects the problem-solving skills of biodiversity content.

According to the problem-solving skill aspects, the highest aspect in both classes was the self-correct aspect. Most of the students wrote down several good and relevant-to-questions alternative solutions. Whereas, the lowest aspect in both classes was the list aspect. This indicates that the students were less capable of analyzing problem-based story questions. This is similar to Sumartini (2016) stating that students' problem-solving skills need support by using an appropriate learning model. One learning that capable of improving problem-solving skills is problem-based learning.

The effect on the improvement of biodiversity learning can be analyzed according to the

PBL model syntax, namely activities of grouping, reading, discussing, finding solutions to a problem from articles, and presentation.

Apperception was conducted before the learning started to provide a stimulus for students. Teachers provided apperception in the form of images or videos of content related to biodiversity concepts, distribution of flora and fauna, and the utilization and efforts of biodiversity in Indonesia. According to Garnasih (2018), the use of video in apperception could foster interest and motivation during learning. Students observe videos or images on the content. In the control class that used the Direct Learning model with a lecture-discussion method, teachers explained the biodiversity content using PowerPoint. Both the experimental class and control class conducted observation activity on content provided by the teachers. The observation activity was included in the scientific approach stage. This is consistent with Djamahar, Ristanto, Sartono & Darmawan, (2020), opined that observing activity is beneficial for fostering students' curiosity on the learning process.

The problem-based learning is learning started with a problem. The problem is related to the real-world problem of the students yet still in the learning concept targeted to be achieved by the students. The PBL provides an opportunity for students to develop problem-solving skills through the presented complex problem-solving process. This is supported by Kusumaningtias (2013) that PBL is learning that could explore problem-solving skills and critical thinking skills and train students to be a learner and self-regulated.

The PBL model and conventional learning model have strengths for biodiversity content learning (Muhlisin, et al., 2020; Astuti, Nurhayati, Ristanto, & Rusdi, 2019). The PBL model provides a portion for the development of complex problem-solving skills. The implementation of the PBL model offers a full portion of students' skill development in finding solutions to solve the occurred problems. The PBL model encourages students to be active in exchanging information with other students and consequently, greater student involvement in the learning process; thus, it trains students to solve their problems (Istiana&Taufik, 2018).

Students who possess problem-solving skills tend to produce better cognitive learning achievement. This is compliant with Nurlaila (2013) that problem-solving skills play an essential role in developing one's cognition since solving a problem is part of active thinking. Therefore, someone who has problem-solving skills will think about how to solve learning difficulties according to facts. Students who have problem-solving skills will generally attain higher learning achievement.

The characteristic of the PBL model includes students who work together in a group to discuss to solve a problem presented by the teacher. The discussion group allows students to discuss and face a high level of differences in opinion with their group peers (Mukhopadhyay, 2013). This discussion indirectly trains and develops students' problem-solving skills. This corresponds to Fakhriyah (2014) stating that learning conditions such as discussion will allow students to analyze the truth of the existing opinions, explain fact-related matters, and select the best solution to solve problems presented.

The teachers' abilities in determining an appropriate learning model and adjusting it to the subject permit students to play an active role in the learning. The learning process must involve students directly in the investigation process or by examining various reading sources (Ristanto, *et al.,* 2018). Teachers in the PBL model act as a facilitator who is responsible in planning activities and supporting the learning process. Express that in problem-based learning, teachers are facilitators and help students in remembering theoretical knowledge that is relevant to problems encountered and lead students to identify their misunderstanding (Muhlisin, et al., 2020; Astuti, Nurhayati, Ristanto, & Rusdi, 2019). Teachers must follow the learning activity according to the PBL syntax to achieve an effective learning process.

Students will fully involve in learning and act as a learning subject (student center). Students' involvement in the PBL could help in developing problem-solving skills since PBL involves students' abilities to logically, critically, and analytically search and investigate so that they could formulate their solutions. This is supported by Saiful dan Aswan (2006) stating that one of the advantages of problem-based learning is to train students in designing an invention, solving problems faced realistically, and investigating and stimulating their thinking progress to quickly solve problems they faced.

The PBL emphasizes five main activities in learning stages, namely student orientation to a problem, a student organization to learn, guide the individual as well as group investigation, develop and present works, and analyze and evaluate the problem-solving process. The five activities could trigger the students to understand information acquired from various learning sources and to be more active in learning activities. This is consistent with Zubaidah's (2001) statement that the PBL is active reciprocal teaching; it contains teachers' interaction in solving problems to develop student knowledge.

The first activity in the PBL model, which is student orientation to a problem, illustrates student's understanding level on the existing problems. Through the understanding, students learn to manage information generated according to accurate data. In this stage, students will optimally involve in learning since they are required to be actively involved in solving problems selected according to teachers' explanation on articles containing biodiversity issues. This is supported by Pratiwi's (2012) research stating that the activity of student orientation to a problem could train students in analyzing and managing information in the form of facts from the presented problems.

The next activity is students are guided to limit and organize learning assignments related to problems encountered. In this stage, the teachers direct students to be focused on biodiversity problems. An activity of creating questions is a method to improve students' problem-solving skills. Students who have problem-solving skills can arrange and formulate questions appropriately. This statement is supported by Zubaidah (2001) stating that students who ask questions are students with high curiosity.

The following activity is teachers guide the individual and group investigation to encourage students to collect appropriate information so they could solve the existing problems. The investigation activity is an activity that combines students' prior knowledge and new knowledge obtained through information. It is one of the stages in students' problem-solving process in identifying important information to solve problems. This is compliant with Sudarman (2007) stating that the group and individual investigation stage provides an opportunity for students for independent learning in searching for a solution in a problem-solving process.

In the next activity, students can develop their problem-solving skills by presenting their works or discussion results of solving biodiversity problems and developing their concept mastery through their activeness in discussion written down in an LKPD (student worksheet) and present them. This activity occurs when students do not understand words in the problem articles. They are encouraged to understand the content according to the trusted sources. In the final stage, analyze and evaluate problem-solving process, students reflect on the investigation and processes employed during the problem-solving activities, whereas students along with other students must respond.

The results of the learning implementation observation indicate that the percentage of the implementation by the teacher and students in the experimental class with problem-based learning model was greater than the control class. This suggests that there was a good interaction between the teacher and the students in the experimental class; hence, the learning implementation was good that affected the average score of the problem-solving skills. Both the PBL model and conventional model emphasize group discussion for students. The PBL model, however, stimulates students to think to understand reading and the writing process; thus, it sharpens problem-solving skills. The conventional model, on the contrary, merely enhances the interaction between the students.

The problem-solving skills had improved in learning, yet some students still had low problem-solving skills. Almost all students could identify problems found; some students, however, still struggled in determining appropriate solutions; thus, they relied on their group peers. Moreover, several students had a difficulty in expressing their opinion and were embarrassed to ask questions during group presentation and lack of opportunity was their excuse for the situation.

## CONCLUSION

The research concluded that there was an effect of the problem-based learning model on students' problem-solving skills of biodiversity content.

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