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The Effect of Problem-Based Learning Model Assisted by Vee Diagram on Students' Problem-Solving Ability

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ABSTRACT

This study aims to determine the effect of the Problem-Based Learning model assisted by vee diagrams on the problem-solving skills of class X SMA 7 Tasikmalaya students in the 2023/2024 school year on environmental change material. The research method used is a quasi-experiment with Posttest Only Control Group Design. The population in this study were all class X consisting of 12 classes with a total of 450 students. Sampling using purposive sampling technique, namely class X-E8 as the experimental class, class X-E12 as the positive control class, and class X-E6 as the negative control class. The instrument used is a test in the form of a description questions as many as 8 questions of problem-solving ability. The data analysis technique used was the One-Way ANOVA test and LSD (Least Significant Difference) test. Based on the results of data analysis and hypothesis testing, the value of Sig. 0.001 <0.05 means that there is an effect of Problem-Based Learning model assisted by vee diagram on students' problem-solving ability. The LSD (Least Significant Difference) test results show that the Problem-Based Learning model assisted by vee diagrams affects on students' problem-solving skills compared to the Problem-Based Learning model and the Discovery Learning model.

Keywords: problem-based learning; problem-solving ability; vee diagram

INTRODUCTION

The 21st century is a century based on science and technology that requires highly skilled human resources to be able to master various fields (Ramdani *et al*., 2019). One of the things that is increasingly important in the 21st century is education to ensure that students have various skills, namely learning and innovation skills, skills in using technology and information media, and can work and survive by using their life skills (Fajri *et al*., 2021). One of the most crucial 21st-century abilities that students must possess is problem-solving ability. Problem-solving ability is a person's ability to find solutions to problems encountered (Sari *et al*., 2019). Problem-solving ability is a basic ability that a person has in solving a problem by involving critical, logical, and systematic thinking (Jayadiningrat & Ati, 2018).

The problem-solving ability of students is one of the most important abilities developed to hone students' structured thinking patterns in solving a problem using effective and systematic steps (Anggraeni *et al*., 2023). Problem-solving skills according to the Program for International

Student Assessment (PISA) report the problem-solving skills of students in Indonesia are still relatively low compared to other member countries, indicated by the results of the assessment in the science field of 396 in 2018, 7 points lower than the test results in 2015 which reached a value of 403. In the assessment, the main thing that is measured is the ability of students in various countries to understand and apply school knowledge to everyday problems (Hidayanti *et al*., 2023).

Based on the results of observations during teaching internship practice from October to November 2023 and based on the findings from interviews with biology teachers in class X at SMA 7 Tasikmalaya as well as conducting preliminary studies, it shows that the average score of problem-solving ability is 57, which is included in the low category. Based on the results of the problem-solving ability obtained, the problem-solving ability of students still needs to be pursued by providing treatment in learning. One of them is by using a learning model because the learning model applied still uses the Discovery Learning model so students are less trained in honing structured and systematic thinking patterns in solving a problem. One of the models that can be used is the Problem-Based Learning (PBL) learning model because the Problem-Based Learning (PBL) model is an active, innovative, and learner-oriented learning model (Azizi, 2019; Astutik & Umami, 2023).

The Problem-Based Learning (PBL) model is a learning model that exposes students to real problem situations found in the surrounding environment as a basis for learning and these problems can teach students something. The purpose of this problem-based learning activity is the activeness, creativity, and ability of students to solve the problems faced (Nomleni & Nubatonis, P, 2020). If students in learning are faced with a problem, then students will get used to looking for and finding solutions to the problems they face (Triyanto & Prabowo, 2020). However, the Problem-Based Learning (PBL) model has shortcomings, namely sometimes experiencing obstacles due to unclear directions in solving problems. Therefore, to overcome these shortcomings, the application of the Problem-Based Learning (PBL) model needs to be assisted by a vee diagram to help organize a more interesting problem-solving process (Sanova, 2013).

Problem-Based Learning (PBL) model assisted by vee diagram, is a problem-based learning model with syntax or learning stages consisting of problem orientation, organizing activities, guiding students' investigations, presenting the results, and analysis and evaluation. The application of vee diagrams in the Problem-Based Learning (PBL) model is used in the second, third, and fourth syntax, namely in organizing activities, guiding students' investigations, and presenting the results. In the syntax of organizing activities, students are divided into small groups to work on worksheets with the help of vee diagrams to help manage the process of solving a problem by attracting and structuring it so that it can be easily solved (Puspita et al., 2018). In the syntax of guiding students' investigations, students look for information related to the problems contained in the worksheet, using vee diagrams the collection of information will be more directed. In the syntax of presenting results, students present vee diagrams to facilitate students in communicating the investigation results so that it will be more organized. The

Problem-Based Learning (PBL) model assisted by vee diagrams can be used on environmental change material. Environmental change material can train problem-solving skills because this material is related to the real world (Sado *et al*., 2020). Environmental change material is closely related to daily life, so it has the potential to develop problem-solving skills (Hidayanti *et al*., 2023). Based on the background that has been described, the purpose of this study is to determine the effect of the Problem-Based Learning (PBL) model assisted by vee diagrams on students' problem-solving skills on environmental change material in class X SMAN 7 Tasikmalaya Academic Year 2023/2024.

METHOD

The type of research applied in the present research was quantitative with quasi-experimental. The research design used in this study was Post-test Only Control Group Design in Table 1 below.

Table 1. Research design

Group	Treatment	*Posttest*
Experimental Class	X_1	O
Positive Control Class	X_2	O
Negative Control Class	X_3	O

Source: (Creswell, 2014)

Description:

X_1 : Learning using the Problem-Based Learning (PBL) model assisted by vee diagram
X_2 : Learning using the Problem-Based Learning (PBL) model
X_3 : Learning using the Discovery Learning (DL) model
O : Posttest scores of the experimental class, positive control class, and negative control class

This research was conducted in May in class X of SMAN 7 Tasikmalaya. The population in this study was the entire class X SMAN 7 Tasikmalaya Academic Year 2023/2024 as many as 12 classes with a total of 450 students. While the sample in this study was as many as 3 classes with a sampling technique that is non-probability in the form of purposive sampling. The sampling was considered based on the results of discussions with the biology teacher. In addition, the three classes were taught by the same teacher using the same teaching method. The samples used were X-E8 as an experimental class with 37 students, X-E12 as a positive control class with 38 students, and X-E6 as a negative control class with 37 students. The purpose of using a positive control class and a negative control class is to make it easier to see or determine whether the effect observed in the experimental class is caused by the treatment or by other factors. The data collection technique in this study was in the form of a problem-solving ability test. The research instrument used in the form of a problem-solving ability description test on environmental change material has as many as 12 questions. Data analysis techniques using the

One-Way ANOVA test and LSD (Least Significant Difference) further test. Before testing the hypothesis, the data obtained were previously tested with a validity test, reliability test, normality test, and homogeneity test.

RESULT AND DISCUSSION

This study aims to determine the effect of the Problem-Based Learning (PBL) model assisted by vee diagrams on students' problem-solving skills on environmental change material. The data obtained in this study in the form of posttest results of students' problem-solving skills in the experimental class, positive control class, and negative control class which can be seen in Table 2 below.

Table 2. Posttest statistical data of problem-solving ability

Statistics	Experiment	Positive Control	Negative Control
Number of samples	37	38	37
Maximum score	91	91	88
Minimum score	44	47	34
Range	47	44	53
Mean	75.93	72.37	66.64
Standard deviation	9.85	9.34	11.38
Variance	97.04	87.38	129.69

Table 1 shows that the average posttest value of the problem-solving ability of experimental class students is higher at 75.93 compared to the positive control class at 72.37 and the negative control class at 66.64.

Furthermore, the results of the analysis prerequisite test which includes the normality test using the Kolmogorov-Smirnov test and the homogeneity test using the Levene test, the data population comes from a normally distributed population, and the data variance is homogeneous. The results of the prerequisite analysis test are presented in Table 3 and Table 4 below.

Table 3. Data normality test results

Tests of Normality				
	Kelas	Kolmogorov-Smirnov[a]		
		Statistic	Df	Sig.
Problem-Solving Ability	Experimental Class	.138	37	.073
	Positive Control Class	.139	38	.063
	Negative Control Class	.142	37	.058

Based on Table 3, the data from the problem-solving ability test results of experimental class students, positive control class, and negative control class have a sig value. > 0.05, meaning that all data comes from a normally distributed population.

Table 4. Data homogeneity test results

Test of Homogeneity of Variances					
		Levene Statistic	**df1**	**df2**	**Sig.**
Problem-Solving Ability	Based on Mean	.434	2	109	.649
	Based on Median	.326	2	109	.723
	Based on the Median and with adjusted df	.326	2	103.995	.723
	Based on trimmed mean	.388	2	109	.679

Based on Table 4, the data from the problem-solving ability test has a significance value of 0.649, so the data has a sig value. > 0.05, meaning that all data has a homogeneous variance.

Based on the results of the prerequisite analysis test, shows that the data is normally distributed and homogeneous, then the hypothesis test is carried out with the One-Way ANOVA test which is presented in Table 5 below.

Table 5. Hypothesis test results (One-Way ANOVA)

ANOVA					
Problem-Solving Ability					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1626.252	2	813.126	7.778	.001
Within Groups	11395.570	109	104.547		
Total	13021.822	111			

Based on Table 5 shows that the significance value of problem-solving ability is 0.001 where the value is <0.05, then H_0 is rejected, so it can be concluded that there is an effect of the Problem-Based Learning (PBL) model assisted by vee diagram on problem-solving ability.

After the One Way, ANOVA hypothesis test is continued with the LSD (Least Significant Difference) test. The LSD (Least Significant Difference) test was used to determine the significance of differences in students' problem-solving skills in each learning model, both the Problem-Based Learning (PBL) model assisted by vee diagrams, the Problem-Based Learning (PBL) model and the Discovery Learning (DL) model. The LSD (Least Significant Difference) test results are presented in Table 6 below.

Table 6. Summary of LSD (Least Significant Difference) test results

Multiple Comparisons						
Dependent Variable: Problem-Solving Ability						
LSD						
Class	**Class**	**Mean Difference**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Experimental Class	Positive Control Class	3.561	2.362	.135	-1.12	8.24
	Negative Control Class	9.290*	2.377	.000	4.58	14.00
Positive Control Class	Experimental Class	-3.561	2.362	.135	-8.24	1.12
	Negative Control Class	5.730*	2.362	.017	1.05	10.41
Negative Control Class	Experimental Class	-9.290*	2.377	.000	-14.00	-4.58
	Positive Control Class	-5.730*	2.362	.017	-10.41	-1.05

The results of the LSD (Least Significant Difference) test from the One-Way ANOVA test of problem-solving ability are presented in the form of notations in Table 7 below.

Table 7. LSD notation of problem-solving ability

Class	**Mean**	**Std. Error**	**95% Confidence level**		**LSD Notation**	
			Lower Bound	**Upper Bound**		
PBL + DV	75.93	1.619	72.65	79.22	a	
PBL	72.37	1.516	69.30	75.44	a	
DL	66.64	1.872	62.84	70.44		b

Based on Table 4.13 shows that the notation for the problem-solving ability of the experimental class (PBL + DV), positive control class (PBL), and negative control class (DL) is a, a, b. between the experimental class and the positive control class has the same notation, namely a, meaning that the two classes are not significantly different. However, the negative control class and the experimental and positive control classes have different notations, namely b. This shows that the experimental and positive control classes are significantly different from the negative control classes. The comparison of the average posttest scores of problem-solving skills of the three classes can be seen in Figure 1 below.

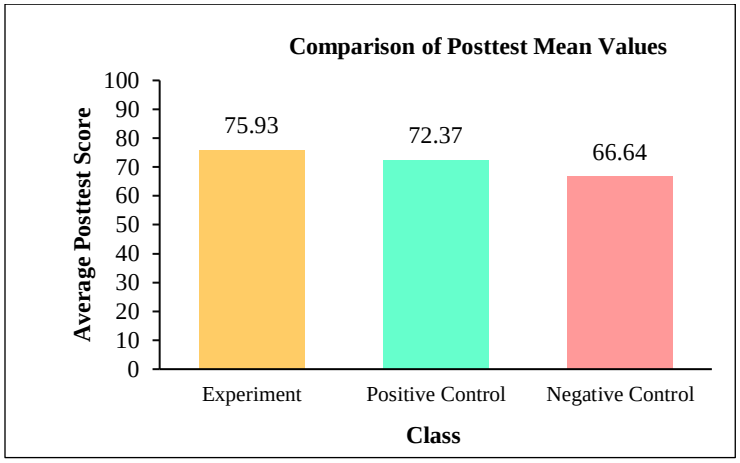

Figure 1. Diagram of average posttest score of problem-solving ability

Based on Figure 1, shows that there is a difference in the average posttest score of problem-solving ability between the three classes. The data shows that the average post-test score for the experimental class is 75.93, the positive control class is 72.37, and the negative control class is 66.64. Based on the average value, it can be concluded that the experimental class is superior to the positive control class and the negative control class.

The problem-solving ability indicators used in this study refer to the problem-solving ability indicators from the University of Southern Maine (2012) in Badriah *et al*., (2023) which consist of defining the problem, developing a plan to solve the problem, collecting and analyzing information, interpreting findings and solving the problem. A comparison of the average post-test scores in each indicator from the three classes can be seen in Figure 2 below.

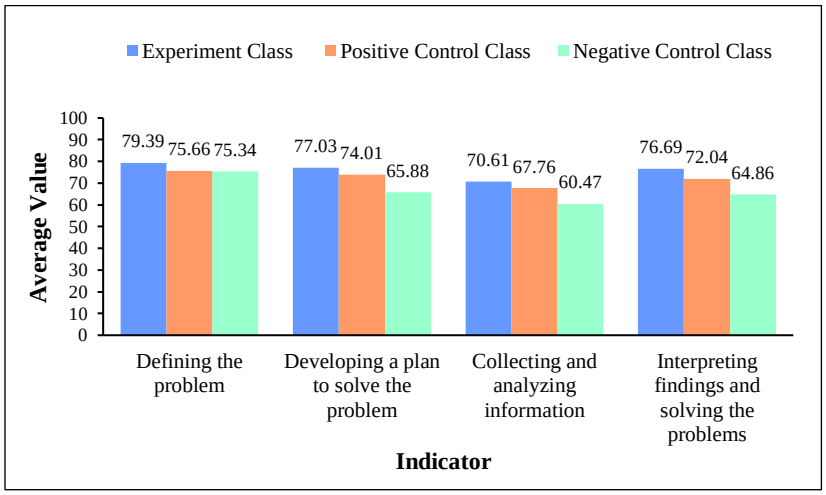

Figure 2. Diagram of average posttest score for each indicator of problem-solving ability

Based on Figure 2, shows that there is a difference in the average value of problem-solving ability indicators between the experimental class, positive control class, and negative control class. The average value of the highest problem-solving ability is in the indicator of the problem 79.39, while the average value of the lowest problem-solving ability is in the indicator of collecting and analyzing information of 60.47. Further discussion on each indicator of problem-solving ability can be seen as follows.

Defining the problem: In the first indicator, students are required to define the problem appropriately according to the problem that has been presented. Defining the problem is the first step in problem-solving ability. Based on the test results obtained on this indicator, the average value of the experimental class was 79.39, the positive control class was 75.66, and the negative control class was 75.34.

Developing a plan to solve the problem: In the second indicator, students make plans to solve problems, students are required to express solutions to the problems that have been presented. Based on the test results obtained on this indicator, the average value of the experimental class was 77.03, the positive control class was 74.01, and the negative control class was 65.88.

Collecting and analyzing information: In the third indicator, students collect and analyze information about the causal factors of the problems that have been presented. Based on the test results obtained on this indicator, the average value of the experimental class was 70.61, the positive control class was 67.76, and the negative control class was 60.47.

Interpreting findings and solving the problem: In the fourth indicator, students are required to determine the most effective solution to solve the problem that has been presented with a reason. Based on the test results obtained on this indicator, the average value of the experimental class was 76.69, the positive control class was 72.04, and the negative control class was 64.86.

The application of the Problem-Based Learning (PBL) model assisted by vee diagrams influences problem-solving skills because students are trained to solve problems systematically. In addition, by using vee diagrams the problem-solving process is more structured and students experience a new learning process with the help of vee diagrams. According to Suryaningsih (2022) vee diagrams can train students to find solutions to problems. The learning process using the Problem-Based Learning (PBL) model assisted by vee diagrams, encourages students to identify a problem and then look for solutions to problems by analyzing and managing information so that students' solving skills can be trained.

Figure 3 was an example of a vee diagram created by students in their groups in the experimental class using the Problem-Based Learning (PBL) model assisted by vee diagrams. The students began creating vee diagrams begin with a focus question and ended with a knowledge claim. The solutions produced by students vary based on the results of the investigation and the collection and analysis of information obtained. Then students choose the best solution from several solutions expressed.

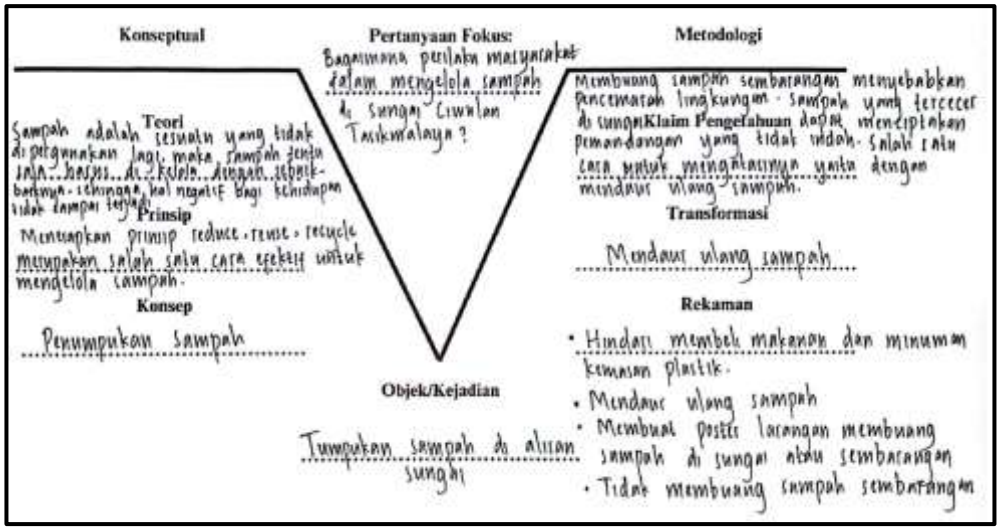

Figure 3. Vee diagram of learner outcomes in the experiment class for group 1

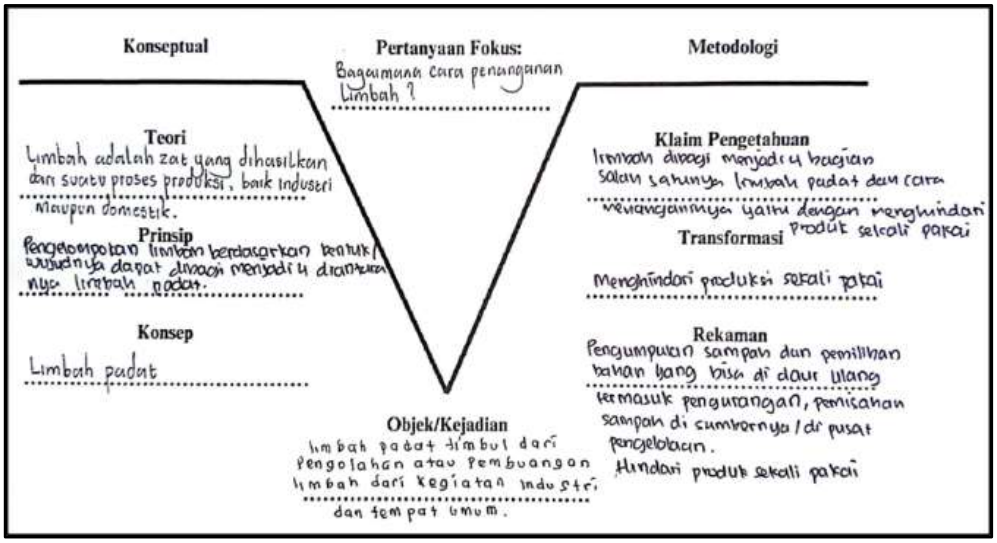

Figure 4. Vee diagram of learner outcomes in the experiment class for group 2

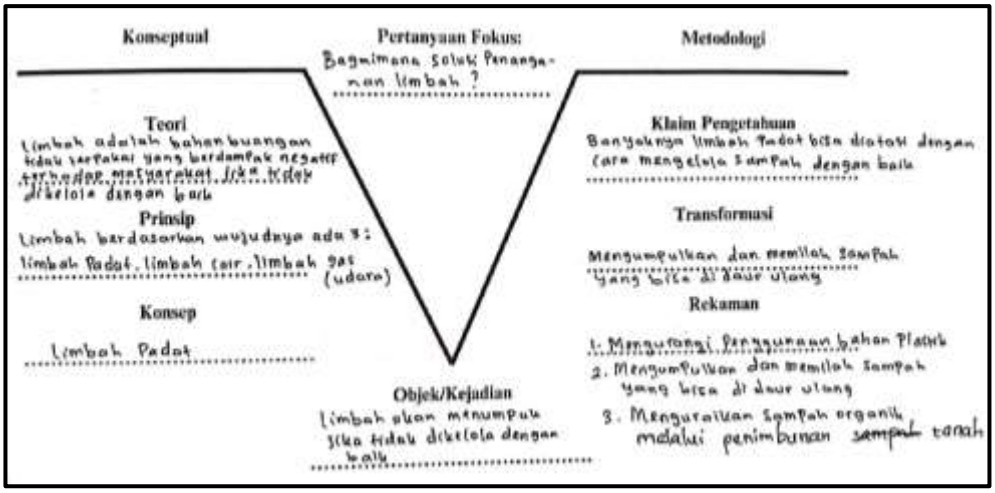

Figure 5. Vee diagram of learner outcomes in the experiment class for group 3

The experimental class using the Problem-Based Learning (PBL) model assisted by vee diagrams has five syntax or learning stages. In the first stage of the PBL syntax, problem orientation, students were encouraged to identify a real problem to motivate them to actively engage in problem-solving activities. During the learning process using the Problem-Based Learning (PBL) model, when students oriented real problems related to the learning material, it helped them define the problems (Helmi & Selaras, 2024). When students were able to define the problem, it made them more sensitive to understanding the existing issues, facilitating their transition to the next step of problem-solving (Wicaksana *et al*., 2023). In the second PBL syntax, organizing activities, students were divided into small groups to find solutions by working on worksheets provided by the teacher (Ionita & Simatupang, 2020). At this stage, the teacher assisted students in determining tasks related to the problems they had been given (Wulandari *et al*., 2023). Working on worksheets students are assisted by vee diagrams to help organize the process of solving a problem by attracting and structuring is so that it can be easily solved (Puspita *et al*., 2018).

In the third PBL syntax, guiding students' investigations, students sought information related to the problems in the worksheet to obtain appropriate explanations and solutions. This activity facilitated students in creating and developing ideas for the problem-solving process (Ionita & Simatupang, 2020). The use of vee diagrams on worksheets trains learners to collect information and build information on problems that have been formulated so that learners can collect more directed information (Laelasari & Anggraeni, 2017). In the fourth PBL syntax, presenting the results, each group presented the outcomes of their problem-solving efforts through discussions, with the teacher providing assistance during these presentations (Suardana, 2019). The presentation of results was conducted through group presentation activities. Learners present vee diagrams to make it effective in embedding new concepts so that it can make learners' thinking more systematic and organized (Danisa *et al*., 2015). In addition, through vee diagrams, students will be skilled in concluding the results of the investigation, so students will be skilled

in communicating when presenting the results of the investigation (Suryaningsih, 2022). In the fifth PBL syntax, analysis and evaluation, the teacher assisted students in analyzing and evaluating the investigation process they had carried out (Astuti, 2019).

The positive control class that uses the Problem-Based Learning (PBL) model also has syntax or learning stages. However, the difference with the experimental class is that the positive control class does not use the help of vee diagrams in the syntax. Then the negative control class that uses the Discovery Learning (DL) model has six syntax or learning stages. In the first stage of the DL syntax, namely stimulation, students are given a stimulus by presenting a picture of various environmental pollution that occurs so that students focus on environmental change material. In the second DL syntax, namely problem statement, students identify problems related to the picture and ask a question. After that, the teacher identifies various questions from students to be summarized and focused on by the learning objectives. In the third DL syntax, namely data collecting, students are given worksheets to help students collect data. The worksheets are done in groups. At this stage, the teacher monitors each group during data collection. In the fourth DL syntax, namely data processing, students conduct discussions with their groups regarding the results of data collection and answer questions in the data processing section. In the fifth DL syntax, namely verification, students are facilitated to convey the results of worksheet work through presentation activities, and other students respond with questions or suggestions. In addition, at this stage, the teacher reinforces concepts regarding environmental change material. In the last stage, namely generalization, students are allowed to convey conclusions from learning.

Based on the posttest results of the three classes, the average value obtained between the experimental class, positive control class, and negative control class has a difference. The average posttest value of the experimental class was 75.93, while the positive control class was 72.37 and the negative control class was 66.64. The average value obtained among the three classes is in the medium category, so to see which is superior, namely from the highest average value. The highest post-test average value is in the experimental class that uses the Problem-Based Learning (PBL) model assisted by vee diagrams. This shows that there is an effect of the Problem-Based Learning (PBL) model assisted by vee diagrams on students' problem-solving skills. These findings aligned with the research by Asiyah *et al*., (2021), which stated that the Problem-Based Learning (PBL) model could improve students' problem-solving skills. This was because, during the learning process, students were required to solve problems, seek as much information as possible, and analyze it to develop solutions. Moreover, according to Nirwana and Wilujeng (2021), the use of the Problem-Based Learning (PBL) model, assisted by vee diagrams, encouraged students to apply scientific methods in the problem-solving process.

In the learning process using the Problem-Based Learning (PBL) model, the learning stages can stimulate students to solve a problem. This is in line with the opinion of Rahmawati (2024) who stated that learning using the Problem-Based Learning (PBL) model students actively participate in each stage of the problem-solving process and make learning more meaningful. In addition, the opinion of Ionita and Simatupang (2020) stated that the Problem-

Based Learning (PBL) learning model requires students to learn the material by solving an authentic problem so that it influences students' problem-solving skills. In addition, by using a vee diagram the problem-solving process is more organized with a vee diagram. This is in line with Ratnaningrum *et al*., (2016) this suggested that one way to organize the problem-solving process is to use a vee diagram.

The Problem-Based Learning (PBL) model assisted by vee diagrams is applied to environmental change material because in this material students will be faced with problems regarding the environment relevant to daily life. In line with Sado *et al*., (2020) this stated that environmental change material can train problem-solving skills because this material is related to the real world. In addition, according to Hidayanti *et al*., (2023) environmental change material is closely related to daily life, so it has the potential to develop problem-solving skills.

CONCLUSION

The vee diagram-assisted Problem-Based Learning (PBL) model has an impact on students' problem-solving abilities regarding environmental changes in class X at SMA 7 Tasikmalaya for the 2023/2024 academic year. The vee diagram-assisted Problem-Based Learning (PBL) model influences problem-solving skills because students are trained to address issues systematically, and the problem-solving process becomes more structured. Additionally, students experience a new learning process with the aid of the vee diagram. Based on the research findings, shows that the use of the vee diagram-assisted Problem-Based Learning (PBL) model can improve students' problem-solving skills. However, research using the Problem-Based Learning (PBL) model aided by vee diagrams requires a considerable amount of time for implementation, as the students are still not accustomed to its use. In addition, this research was conducted with a small sample and only on environmental change material, which may limit the generalization of the research results.

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