



## Improving Problem-Solving Skills Using ESD Integrated PBL Models Assisted with the Greenhouse Limas Project

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### Abstract

**Improving Problem-Solving Skills Using ESD Integrated PBL Models Assisted with the Greenhouse Limas Project.** Problem-solving skills in high school students are still low, there are still many students who have not been able to develop problem-solving so innovative learning models are needed in learning at school. This study aims to describe the implementation of the ESD-integrated PBL model utilizing greenhouse lime to improve students' problem-solving skills. The type of research used in the research is this research using the type of Quasi-Experimental Design research. The participants in this study are students of class X Mipa at one of the high schools in Pamekasan Regency. This study uses 2 classes, namely the control class and the experimental class. Based on the results of the research, it was concluded that the ESD-integrated PBL model learning activities to improve the solving skills of class X students were carried out with an average percentage of 95.55% in the very good category. The application of ESD-integrated PBL model learning can improve students' problem-solving skills. This is characterized by 1) the results obtained from the post-test score are higher than the results of the pre-test with an N-Gain of 0.78 in the high category, while in the control class, the results of the N-Gain obtained are 0.67 with the medium category 2) the results of the post-test of the two classes in the independent test are 0.162 which means that the significant value is greater than 0.05, then  $H_1$  is accepted. Thus, there was a significant difference in the mean post-test scores of the experimental class and the post-test of the control class. Students' responses to the application of ESD-integrated PBL model learning to improve students' problem-solving skills based on the analysis of the response questionnaire obtained a positive response in the experimental class with an average percentage above 70%, which means that the points on the student response questionnaire were in a good category.

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## INTRODUCTION

The changing times have experienced very rapid development due to increasing progress every year, resulting in human thought patterns increasingly developing and innovating to create something new. Education is defined as a learning process in which there is hard work to realize a cultural heritage that is passed on to future generations. Education is realized through comfortable learning facilities and atmosphere to start learning activities in which students can develop their potential and the ability to be active in improving religious values, noble morals, personality, attitudes, and skills needed in the future to enter the era of globalization which is increasingly developing and experiencing increasingly rapid progress (Rahman et al., 2022). Efforts to develop learning carried out by students require an active role to be able to acquire new knowledge by using the sequence of the PBL model.

The learning model is a series of conceptual ideas developed to be used as a reference and guide during the learning process. The learning model helps teachers to teach and guide students to be able to obtain information, ideas, concepts, knowledge, and skills in the ability to express ideas that are used to deal with problems in the surrounding environment. There is a problem-based learning model that is an innovation in implementing learning to students, namely by implementing the PBL model. The PBL model is one of the innovative learning models that focuses on problem-solving activities and problems that have not been resolved properly so in-depth solutions are needed through groups (Rizki, 2020). The PBL model is a learning model accompanied by real problems, obtaining information, and solving problems by solving existing problems (Alatas, 2020).

One solution in building the abilities of each student is to apply the PBL learning model which integrates Education for Sustainable Development (ESD). According to Novianti (2023), ESD is an education that is directed towards sustainable development which includes innovative insights to provide awareness to the community about the global environment, while the community can contribute directly and actively to supporting sustainable development. The research conducted by Zulfah (2024) stated that ESD emphasizes steps to provide new perspectives and ways of thinking in solving a problem for students.

Education is the starting point in introducing sustainable development. The ESD approach is expected to be able to solve problems that exist in local life and globally. Implementing ESD-integrated PBL can also help students solve local problems by paying attention to sustainable development (Agusti, 2019). Based on the results of research conducted by Zulfah (2024), the application of the PBL model which is actively integrated with ESD can improve skills from the results of the learning that students have carried out. Sustainable development is needed to improve the quality of education for students as they face life that they experienced and passed on for the sake of sustainability for the next generation by utilizing these natural resources without exceeding existing capacity (Purnamasari, 2021). The sustainable concept itself has the concept of living better amidst natural limitations and maintaining balance by having three main components of ESD which can be seen from a social, economic, and environmental perspective (Klarin et al., 2018; Purnamasari, 2021). It is hoped that this sustainable development will be able to provide solutions to existing problems in the surrounding environment.

Research conducted by Firmasnyah (2022) suggests that the application of the problem-based PBL model can result in innovation to increase in acquiring skills to be able to solve problems that occur in local life. The implementation of the PBL model seeks to understand and understand the learning concepts taught through questions about the problems that occur which are presented at the beginning of the lesson to train students to complete solutions to the problems they face. Problem-solving skills are one of the intellectual skills found in every student to obtain basic knowledge and skills from the knowledge they have (Tamrin, 2022). Problem-solving skills are individual basic skill competencies in dealing with solutions to a person's process of thinking critically, logically, and systematically (Rahmatika, 2022). The PBL model actively involves students going through a series of learning processes that involve active, collaborative, and student-centeredness (Aripin, 2021).

Problem-solving skills are a necessity for students in the 21st century, so it is necessary to know students' problem-solving skills. According to Lestari (2019), problem-solving skills are an action to solve a problem or a process that utilizes the knowledge they have in solving a problem. The importance of improving problem-solving skills cannot be separated from its role in life, namely to develop a person's ability to face a problem. The ability to solve problems that are estimated depends on the application of Polya as an effort to track answers to existing problems. Polya suggests 4 steps. These steps are understanding the problem, planning a solution, solving the problem according to plan, and rechecking/evaluating. Implementation in solving problems that can be realized in school learning, namely physics material regarding global warming.

Global warming is one of the materials found in high school physics lessons. Physics subjects are defined as lessons based on natural phenomena that occur in life around us that can be found in the surrounding environment (Agusti, 2020). The importance of knowledge about global warming is an effort to increase environmental awareness and global challenges so that the government includes global warming in the physics material for grade X in phase E of the independent curriculum (Putri Anggraeni et al., 2023; Fajrin, 2024).

According to research conducted by the Center of International Forestry Research (CIFR), global warming is a process of trapping long-wave radiation called infrared which will be emitted to the earth due to the presence of gases originating from the greenhouse effect. Gases from the greenhouse effect are naturally present in the atmosphere, these gases are trapped, causing the earth's temperature to increase, resulting in an increase in global warming on earth. One of the impacts of global warming is changing weather, causing salt farmers to have difficulty producing good quality salt. Salt is a raw material used to meet daily needs. Salt is a natural resource obtained from marine sources and used as a complementary ingredient for cooking for the people of Indonesia. In addition to being consumed, salt can also be used as an industrial material. Salt is widely produced in Indonesia, due to the characteristics of Indonesia as a maritime country with a territorial ratio of 3:1 between the ocean and land areas.

Based on interviews with salt farmers that have been conducted, it was found that in Madura, especially in the Pamekasan area, they still use very traditional equipment and processing processes. Weather changes can hamper the salt-making process. The salt-making process requires sufficient sunlight to turn seawater into salt crystals or solid salt. Changing weather conditions due to increasing global warming can hamper the salt-making process. Global warming occurs due to several factors, including vehicle exhaust fumes such as motorbikes, cars, trains, and smoke from factory waste processing. The hampered salt-making process caused by weather changes can affect the duration and quality of the salt produced.

The application of physics concepts in the salt-making process can help teachers to more easily connect physics concepts with the practical process of making salt (Nufus, 2023). In the salt-making process, students can be introduced to the salt-making process related to physics materials in schools. The salt-making process in Madura, which still uses traditional processing and equipment, with the existence of development-based ESD provides a tool that can make salt simply by utilizing the application of the greenhouse effect that occurs in the greenhouse pyramid as an improvement in salt-making in Madura. The salt-making process utilizing the greenhouse pyramid project can help explain the greenhouse effect and its relationship to global warming. Making salt from seawater involves a series of stages that must be carried out which can be seen from physics learning such as from the evaporation of seawater, crystallization, to taking salt grains. Each stage has its physics concept. Success in making salt is greatly influenced by weather conditions.

Increasing global warming causes the greenhouse effect to increase. This global warming causes increasingly changeable weather, causing salt farmers to fail to produce salt due to unpredictable weather. This research provides learning innovations for students in schools to be able to overcome increasing global problems. The solution is to create a greenhouse pyramid project to produce salt by applying the concept of physics, namely the greenhouse effect. This greenhouse effect provides learning to students in dealing with existing problems.

Based on the description of the background of the problem, the application of the ESD Integrated PBL model is an alternative solution to improving students' problem-solving skills to be taught in schools. For this reason, a study entitled "**Improving Problem-Solving Skills Using ESD Integrated PBL Models Assisted With The Greenhouse Limas Project**" was conducted. The importance of this study for teachers as a novelty in teaching material during classroom learning that has never been used before. For students as a provision to gain new knowledge with different learning methods and practice problem-solving skills in dealing with problems that exist

around them. For researchers as an experience and gaining broader knowledge so that later it can be used when becoming a teacher at school.

## METHODS

Type of research used in the study is Study This use type study *Quasi-Experimental Design*. The reason the researcher used the Quasi-Experimental research method was that the research sample used to determine the relationship between variables and clarify the causes of this relationship involved a control group and an experimental group. The number of students in class X-F is 34 students and class X-G is 34 students with an age range of around 15-16 years. Participants in study class X Mipa in one high school in the district Pamekasan. Study This using 2 classes: class control and class experiment. Following This is the form design For study with design *Quasi Experiment Design*:

Table 1. Design Study

Sampling	Group	Pre-test	Treatment	Post-test
Random	Experiment	Y1	X2	Y2
Random	Control	Y1	X1	Y2

Information:

Y1 = *Pre-test value* before given treatment

Y2 = *Post-test value* after given treatment

X2 = Treatment (integrated PBL model ESD-related global warming)

X1 = Treatment (conventional PBL model).

## Data analysis technique

### 1. Analysis Implementability Learning

There were 3 observers used to observe learning directly in class in carrying out learning using the PBL model integrated with ESD in solving problems. Learning implementation analysis is carried out to find out whether a lesson is going well or not. Analysis of the implementation of the learning process using the Guttman Scale with criteria as in Table 2.

Table 2. Guttman Scale Score

Answer	Score
Yes	1
No	0

To determine the percentage of learning implementation, the formula for determining the percentage is used, namely:

$$\text{Percentage (\%)} = \frac{\text{Jumlah skor}}{\text{Skor maksimal}} \times 100\% \quad (1.1)$$

The results of the percentage of implementation of the learning process are categorized according to the percentage category of the adopted rating scale and Riduwan (2015) as in Table 3.

Table 3. Criteria Percentage Rating Scale

Percentage	Category
$0\% < x \leq 20\%$	Very less
$21\% < x \leq 40\%$	Not enough
$41\% < x \leq 60\%$	Enough
$61\% < x \leq 80\%$	Good
$81\% < x \leq 100\%$	Very good

(Riduwan, 2015)

Implementation exists in each stage of the PBL model where place Conclusion is given or No learning the taking place. That conclusion forms "Yes" or "No" sentences.

## 2. Analysis Enhancement Skills Solution Problem

Enhancement Skills solution problem can be used from results score mark *pre-test* and *post-test*. *Pre-test* and *post-test* scores were analyzed use Analysis *N-gain*, if meets the normality and homogeneity tests of the data. Therefore, before using analysis *N-gain*, then must carry out prerequisite tests moreover formerly.

### a. Prerequisite Test Analysis

Prerequisite test analysis shared become several, namely data normality test and data homogeneity test. In research here, the prerequisites used are the normality test and data homogeneity test

$H_0$  said fulfilled if mark significance  $> 0,05$  So that the sample's variant is homogeneous.

### b. Data analysis

#### a) Analysis *N-gain*

Count *N-gain* value using equation 1.2.

$$\text{Normalized gain (g)} = \frac{\text{skor posttest} - \text{skor pretest}}{\text{skor ideal} - \text{skor pretest}} \quad (1.2)$$

Existing *N-gain* value processed can categorized as according to Table 4.

Table 4 Criteria *N-Gain* Score Interpretation

Score	Category
$g \geq 0,70$	Tall
$0,3 \leq (g) < 0,70$	Currently
$g \geq 0,30$	Low

(Wardani & Jatmiko, 2021)

#### b) Paired t-test

Test differently own objective to know influence consequence application of each class to Skills solution problem participant educate. Test differently analyzed using paired t-test If *pre-test* and *post-test* normally distributed.

#### c) Independent sample t-test

Based on the results of normality tests and homogeneity tests, if that *pre-test* data is normally distributed and homogeneous, then can followed by the average similarity test using *the Independent Samples t-test* through the SPSS program with the assumption second variance is homogeneous (*equal variance assumed*) with level significance 0.5 (Ambarsari, 2012).

The hypothesis in the *Independent Samples t-test* is as follows:

$H_0$ : results Study class experiments and classes control at *pre-test* No different in a way significant.

$H_1$ : results Study class experiments and class control at *pre-test* different in a way significant.

Criteria for taking his decision that is:

1. If the value significance more smaller than 0.05 then  $H_0$  rejected
2. If the value significance more bigger than 0.05 then  $H_0$  is accepted.

#### d) Effect Size

*Effect size* is a size that influences something variable to other variables (TELA *et al.*, 2019). To determine *effect size*, then use equation Table 1.3.

$$\text{Effect size} = \frac{(\text{mean skor posttetst}) - (\text{mean skor pretest})}{\text{standar deviasi}} \quad (1.3)$$

*Effect size* can determined using adapted criteria from Lestari, *et al* (2021) as in Table 5.

Table 5. Effect Size Criteria

Intervals	Category
0.00 – 0.20	Very weak
0.21 – 0.50	Weak
0.51 – 1.00	Currently
> 1, 00	Strong

(Lestari *et al.*, 2021)

### 3. Analysis of Questionnaire Sheets Response Learners

Response data participants were educated Then analyzed using a *Likert* Scale with stages as follows:

- a. Count amount score answer questionnaire based on *Likert* Scale score as in Table 6.

Table 6. Likert Scale Score

Score	Answer
1	Very not agree
2	Don't agree
3	Neutral
4	Agree
5	Strongly agree

- b. Recap amount answer participant educate  
 c. Count amount The ideal score is  $5 \times$  amount participant educate  
 d. Analyze response data participant educate with equation 1.4.

$$\text{Response (\%)} = \frac{\text{jumlah skor total}}{\text{skor ideal}} \times 100 \% \quad (1.4)$$

Percentage response participant educate categorized as based on criteria as in Table 7.

Table 7. Criteria Interpretation Analysis Response Learners

Percentage (%)	Criteria
0 – 20	Very less
21 – 40	Not enough
41 – 60	Enough
61 – 80	Good
81 – 100	Very good

(Lestari *et al.*, 2021)

The method used should be accompanied by references; the relevant modification should be explained. The procedure and data analysis technique should be emphasized in a literature review article. The stages and analysis of the research must be explained in detail. The research method should be presented in this section with a caption. Image captions are placed as part of the figure caption, not as part of the image. The methods used in completing the research are listed in this section.

## RESULTS AND DISCUSSION

### Results

#### 1. Analysis Implementability Learning

Data from results implementation learning observed by three observers namely 1 high school physics teacher and 2 are students from a state university. Observation results obtained from observation from the three observers concluded with noticed amount activities carried out at each phase. All amount activities obtained from every phase are calculated to get a

percentage every meeting. Following results of recapitulation implementation learning are shown in the image below.

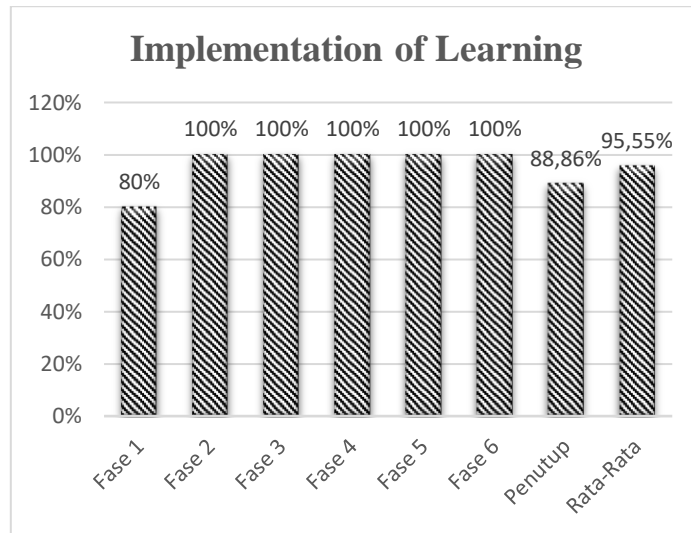


Figure 1. Graph Implementability Learning

Based on Table 1 it is known that the average implementation learning in class experiments using the ESD-integrated PBL model obtained mark overall average percentage amounting to 95.55 % with a very good category. In the introduction, the teacher gives a smile, greet, and greet to signify the commencement of learning to be carried out by the teacher. Stage this is the teacher repeating a little material that has been studied previously, and the teacher conveys objective learning to be done. At stage introduction, this obtained percentage implementation learning of 80% shows category good for start learning.

In the first phase aspect, namely orienting students to problems with an ESD approach or integration in the experimental class, the percentage of implementation value was 100% with an outstanding category. Students were given trigger questions about problems in the surrounding environment, one of which was the phenomenon of salt farmers in Pamekasan failing to produce salt due to tidal flooding due to global warming, then students analyzed the facts about the causes of the tidal flood. In phase second, namely organizing students with an integrated ESD (Education for Sustainable Development) approach in the experimental class, the percentage of implementation was 100%. The teacher formed groups and provided student worksheets for each group. In the third phase, namely guiding the investigation with an integrated ESD approach, the percentage of implementation value was 100% with a very good category. The fourth phase stage is developing and presenting work with an ESD approach or integration in the class conducting the practicum, namely class X-G as the experimental class, which has a percentage implementation value of 100% with an outstanding category.

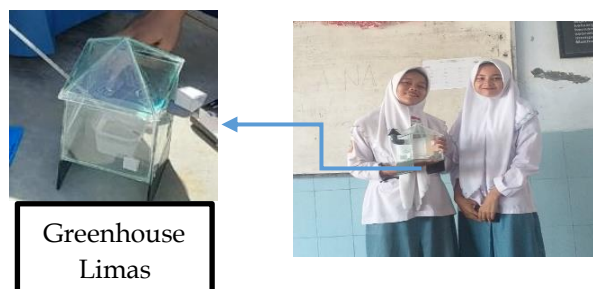


Figure 2. Phase 4 Developing and Presenting Work Results

The stages in the fifth phase, namely analyzing and evaluating the problem-solving process in the experimental class, obtained the implementation of learning with a percentage of 100% with a very good category. The teacher expressed appreciation to students who were active during learning activities.

## 2. Analysis Skills Solution Problem

### a. Prerequisite Test Study

The guidance provided in chap was previously used for analyzing results using the analysis test using prerequisite test, N-gain analysis, paired t-test, independent test, and *effect size*.

#### a. Normality test

A normality test is something test used to know samples that have been taken normally distributed or Not. Determine mark significant value is obtained results exceed so that the data obtained from the results research of each class normally distributed, as shown in Table 8.

Table 8. *Pre-test* Normality Test Data Results

No	Class	Kolmogorov-Smirnov		
		Statistics	df	sig
1	<i>Pre-test</i> Class Experiment	0.146	34	0.064
2	<i>Pre-test</i> class control	0.148	34	0.056

Based on Table 9. shows that the data processed from the results study show that results acquisition mark *pre-test* from class experiment conclusions can be drawn taken from the research carried out the data was normally distributed. Furthermore, for results mark the *post-test* shown in Table 9.

Table 9. *Post-test* Normality Test Data Results

No	Class	Kolmogorov-Smirnov		
		Statistics	df	sig
1	<i>Post-test</i> Class Experiment	0.143	34	0.076
2	<i>Post-test</i> class control	0.147	34	0.059

Based on Table 1.9 shows that the data processed from the results study shows that results acquisition mark *post-test* from class experiment conclusions can be drawn from The research carried out the data was normally distributed.

#### b. Homogeneity Test

The homogeneity test is one of the prerequisite tests used to prove whether samples from a population have the same variance or not (Widana & Mulia, 2020). The data obtained from research conducted is shown in Table 10.

Table 10. Obtaining Homogeneity Test Data

Class	Sig.	Information
<b>Experiment</b>	0.493	Distributed data in a way homogeneous
<b>Control</b>		

Based on Table 10, it is obtained mark results from the second class with the derived values from the results *pre-test* and *post-test* using SPSS obtained sig value. Amounting to 0.493 which states distributed in a way homogeneous.

#### c. Paired t-test ( *Paired Sample t-test* )

The purpose of the difference test is to determine the effect of the implementation of each class on students' problem-solving skills. The difference test is analyzed using a paired t-test if the pre-test and post-test are normally distributed. Paired t-test calculation results are shown in Table 11.



Table 11. Paired Sample T-test Results

Class	Treatment	Average	Sig.(2-tailed)
Experiment	Pre-test	31.32	0.00
	Post-test	85.29	
Control	Pre-test	28.50	0.00
	Post-test	76.97	

Based on Table 11, it is obtained marks results from the second class with the derived values from the results *pre-test* and *post-test* using SPSS obtained sig value. Of 0.00 which states that 0.00 shows that the results, research obtained own mark not enough of 0.05 which means obtained H0 rejected H1 accepted.

d. Independent Sample t-test

Based on the results of the normality test and homogeneity test, if it is found that the pre-test data is normally distributed and homogeneous, then the average equality test can be continued using the Independent Samples t-test. Results of Independent Test testing can seen in Table 12.

Table 12. Independent Sample t-test data results

Test Type	Sig.	t count	t table	df
Posttest	0.162	11,270	1,996	66

Value results are significant in that the value of 0.162 exceeds the significant 0.05. The conclusion that can be taken that is there is difference in average values significant from class post-test scores experiment and class post-test control.

e. N-Gain Analysis

To find out and analyze the relationship between increasing problem-solving skills after implementing the integrated PBL model Education for Sustainable Development (ESD) Results obtained from N-Gain analysis in each class experiment and classes control shown in Table 13.

Table 13. N-Gain Data Results

Class	Average N-Gain	Category
Experiment	0.78	Tall
Control	0.67	Currently

Based on Table 13, shows the N-Gain value is 0.78 with the category high, while in class control the average value of N-Gain obtained 0.67 with the category currently.

f. Calculation *Effect Size*

Effect size is a measure of the influence of a variable on another variable (TELA et al., 2019). The following results are calculated through calculation *effect size* in Table 14.

Table 14. Calculation Results *Effect Size*

Class	Effect Size	Category
Experiment	0.54	Currently
Control	0.48	Weak

Based on Table 14 shows mark results Effect Size calculation explains that the class experiment owns a mark of 0.54 with the category medium, while in class control owns a mark of 0.48 with the category weak.

Problem-solving skills are defined as the ability possessed by each individual to be able to develop the ability to solve problems in everyday life (Nurfatanah, 2019). The purpose of conducting pre-test questions by students is to measure the level of problem-solving skills of students based on the knowledge and skills of students before studying global warming material, and before the ESD integrated PBL model learning is carried out. Furthermore, the post-test questions are aimed at determining the level of problem-solving skills of students

based on the knowledge/skills of students after being given ESD-integrated PBL model learning. The average results obtained from the pre-test and post-test scores of the experimental and control classes are described in Table 15.

Table 15. Pre-test and Post-test Results

Data	Pretest		Posttest		
	N	Eksperimen	Kontrol	Eksperimen	Kontrol
Total Value		1065	969	2900	2617
Average Value		31,32	28,5	85,29	76,97

Based on Table 15 shows the results obtained from the pre-test and post-test scores in the experimental class and control class. In the experimental class, the pre-test score was 31,32, while the control class obtained an average pre-test score of 28,5. In the results of the post-test questions, the experimental class obtained a score of 85,29, while the control class obtained a post-test score of 76,97.

### 3. Analysis Response Learners

Questionnaire results response participant students were filled in by 34 sample participants. The percentage results answer participant educate presented in Table 15 below This. Response sheet participant education consists of 15 items questions.

Table 16. Percentage Data Response Learners

No	Statement	Percentage	Criteria
1	PBL learning integrates ESD into the material global warming is something new thing for I	80%	Good
2	PBL learning integrates ESD into the material global warming made me interested from the moment I first heard it	76%	Good
3	PBL learning integrates ESD into the material global warming and is capable increase interest in learning physics	74%	Good
4	PBL learning integrates ESD into the material global warming makes I more understand material learning	76%	Good
5	PBL learning integrates ESD into the material global warming increases awareness For guard environment	78%	Good
6	Learning material global warming with ESD-integrated PBL models creates more motivation For the Study	74%	Good
7	PBL learning integrates ESD into the material global warming making me skilled in finishing problem-related problems that exist in life daily	78%	Good
8	PBL learning integrates ESD into the material global warming makes me skilled in putting forward opinion	78%	Good
9	PBL learning integrates ESD into the material global warming makes me actively ask teachers and friends	78%	Good

No	Statement	Percentage	Criteria
10	PBL learning integrates ESD into the material global warming makes me actively discuss with teachers and friends	80%	Good
11	PBL learning integrates ESD into the material global warming and helps me answer questions from the teacher with Good	76%	Good
12	PBL learning integrates ESD into the material more global warming interesting For studied	80%	Good
13	ESD integrated PBL learning with training Skills solution problems make me capable find information scientific about issue-related science globally, locally, and personally	78%	Good
14	After ESD integrated PBL learning with Skills solution problem capable apply and relate draft science based on phenomenon science that happens in life real	78%	Good
15	Learning associated physics with problems in life daily based on phenomenon natural related to ESD-integrated PBL learning can increase Skills solution problem	76%	Good

Based on Table 15 the result's highest value of 80 % is found in statements numbers 1,10,12 which states that the PBL model is integrated with the ESD approach and is something new thing Not yet Once taught previously, learning felt more active discuss For finish existing problems as well as interesting For studied.

## Discussion

### 1. Implementability Learning

PBL model learning is one of the learning-based model problems Table 1 lists results in observations carried out by three observers for observing the implementation of the PBL model used in conveying material global warming at the moment learning taking place. An ESD-integrated PBL model was implemented with two meetings. Meeting First use stages among other things, introduce participants to educate on the problem,

Phase First that is to orient participants on the problem's implementation by 100%. In this phase, the teacher provides problems that exist around them and requests participants To convey their opinion on the answer he has For finish problems around you We. Giving phase This makes participants think about solving existing problems as well as finishing the existing situation. Problems that occurred at the time like the failure resulting from salt harvest change and changing weather caused increasing global warming enhancers. The impact of global warming causes salt farmers in the process of making it experience failure, so requires completion of problem the. Solutions provided by participants educate from reducing usage of vehicle personnel such as motorbikes and cars. Smoke coming from material burn vehicles causes increased global warming caused by vehicle exhaust, does reforestation and planting return bare forests help reduce carbon gas dioxide in the earth, as well as reduce disposal of rubbish in a way haphazard? Consequently, the stacker rubbish can cause a polluted environment so that the air produced becomes uncomfortable. The PBL model provides

problem-related problems so that later participants can develop skills in solving problems the PBL model of the problem by what happens in the environment around as experience is used to obtain the information used as an objective Study For increase results study well (Azmi, 2021).

In phase second that is organize participant education for study. Percentage earned in phase This by 100%, where participants are requested to convey opinions about problem lighter given by the teacher. Participants answer questions lighter the with Good. One by one participants can convey ideas about the effort in finishing problem the so the process is to transfer knowledge second the teacher with the participant Educate, Delivery participant educates about the solution to the problem done very interestingly, after the teacher can convey the impact that occurs from global warming. In phase this participants can submit several approaches problem by gathering various information obtained through online media and in book packages so that participants are capable obtain answers to existing problems (Herdiawan, 2019 )

Next, that is phase third helps study individual or group percentage implementation 100 % which was implemented very well. Teachers help explain what should be done through practice after the LKPD sheet is given. Stage this is the teacher instructing the to participant educate them to identify the problem as well as write a formulation that problem will be resolved. Every group collaborates to finish problems that will faced. The teacher as facilitator provides the needed tools and materials will be used as practice and the teacher monitors the way practicum will be carried out by each group, and stage This needs good collaboration from each individual to finish practice until finished. Practice needs to Work the same as the good ones so that can produce results in good learning. Ability to collaborate as well as results Study own linkages One The same others (Sarah, 2023).

In phase four that is develop and present results work. Stage this obtain percentage by 100% with very good description. In phase this, the teacher asked for every group to present results from the discussion group to do the practicum that has been done. Presentation limas house helpful glass in finish problems that exist in the LKPD. Presentation work This form results obtained as well as presented in front class for furthermore will give chance to ask for answers from other groups and also from teachers. When the presentation participant explained the results obtained in a coherent and good. In accordance with the study yeah conducted by Latifah (2018) stated that the PBL model solves problems and needs groups to collaborate to finish existing problems.

The next phase is to analyze and evaluate the solving process problem. This phase gets a percentage of 100% with a very good description. At stage this, the teacher asks for participants educate conclude the conclusion in a way direct. Learning that has been done in a coherent way coherently, then evaluated by the teacher and responded to by the participants to educate if there is a question asked during the learning process that has been done done. Teachers also provide appreciation to participant active learner during the learning and give process motivation to participant educate those who haven't yet role active during learning. Connecting evaluation activity learning physics based on the PBL model in practice learning taking place. Through evaluation of learning there are identified improvements to achieve objective learning that has been compiled (Mutiara et al. 2017; Amalia, 2024).

The PBL model can help participants educate in understanding material learning at school. Learning takes place with Good participants to obtain unknown knowledge Once previously caused skills participants are educated to solve something problems that exist in the environment around can resolved with Good. Study this by the statement from Ananda (2023) states that learning problems have proven to benefit participants in developing the skills he has for adding outlook as well as knowledge gained so that enhancement skills possessed by participants educate. Implementation of the ESD-integrated PBL Model causes participants

educated and can hook problems around them with development sustainable in finish problems encountered. Implementation of PBL-integrated ESD in an Educational context can increase the results of study participant education in a way significant (Pratiwi *et al*, 2019; Zulfah, 2024).

Then, the results observation implementation by the three observers shows that the researcher carry out teaching with complete in accordance activity learning and acquiring very good criteria. In PBL syntax, each aspect is assessed phase with an explanation of each phase. Although thereby there are a number of obstacles faced by teachers during the learning process. These obstacles are related with time participant education taking too long to implement practice.

## 2. Skills Solution Problem

The study has been done to show the results of Skills solution problems encountered from the value of the results obtained from each class experiment and class control. Instrument questions form question description that becomes indicator Skills solution problem. In all classes, it is higher than the mark *pre-test*. Before treatment participants' ESD-integrated PBL model was not capable of answering questions so the results obtained from pre-test scores were still low. Meanwhile, the learning that has been done through participants' ESD integrated PBL model educates capable of getting post-test scores that are far off good from previously so that get results high average post-test scores. N-Gain stages are used to know the enhancement value obtained from participant education from the second class. On results mark *post-test* class experiments applying the ESD integrated PBL model obtain the average value of N-Gain is at a medium level, while in class control without done ESD integrated PBL model treatment gets N-Gain results with category currently. There is a change or enhancement mark Skills solution problem participant teach in class experiment caused by the implementation of the characterized ESD integrated PBL model with use problem existing science around environment public like global warming with issue The tidal flood that occurred in the salt pond was caused by exists global warming with using the PBL model in Skills solution problem expected participant educate understand every step in taking draft as well as draft physics in finish something problem.

The PBL model integrated with ESD in physics learning makes students more courageous in expressing their opinions while taking place in the classroom. The reason for this is that they are given problems to solve them. This problem is solved by implementing ESD to support the future that will come and can be passed on to the next generation by considering the ESD components, namely social, environmental, and economic in the surrounding community. Students are active in expressing their opinions in solving real problems that occur in their environment so that students' problem-solving skills can improve along with topic ideas and ideas conveyed through group discussions when doing practicums. This research is on what has been done by Pratiwi (2019) which states that students can have the ability to understand, apply, analyze, and evaluate learning outcomes so that the process of students gaining knowledge improves the skills they have acquired.

The advantages of implementing the PBL learning model with the ESD approach that has been applied in learning can be seen from the significant results on problem-solving skills where the class that implemented the learning experienced an increase in the experimental class score compared to the control class. The ESD-integrated PBL model provides learning innovation in the classroom and teaches students to overcome problems that exist in the classroom and find solutions to these problems. The purpose of implementing the ESD-integrated PBL model is to provide new knowledge through problems in the surrounding environment so that students can solve problems and provide solutions to these problems. This is by research (Simanjunta, R.M., et al 2023) PBL has the aim of implementing the learning

model with activities to build constructivism and direct student involvement in solving problems. Vygotsky's learning theory suggests that students are directly confronted with new experiences and can solve the problems they face. Vygotsky's learning theory is known as the social-constructivism theory. To gain understanding, students can link new knowledge with their prior knowledge (Inayati, 2022). One of the implications of Vygotsky's learning theory in classroom learning activities is the application of problem-based learning.

### 3. Response Participant Educate

Response participant education shown in Table 15, level response statement that studies ESD on the material global warming using the PBL model is the most interesting is 82%. Results of survey participants show that participants are more involved in lesson learning, especially related to global warming and ways To overcome problems caused by the impacts of global warming. Besides, when using learning (PBL with ESD approach, can be concluded that participants are satisfied or not bored at a time when participants are more interested in the learning provided. This matter is seen from the comment participant learner who gets it average value of 70%. Answer results from participant learner who gets the percentage of 76% show that participants educate faster and understand the material. The ESD-integrated PBL model makes things easier to understand the material, improves motivation to learn, improves Skills in solving problems, pushes participation in activity learning, and makes it easier to respond to teach questions included in the category of good results. Respon participants use a questionnaire sheet where the questionnaire shows the opinions and assessments of students during learning activities. The results of the implementation are assessed by observers and the test results are the results obtained by students when working on pretest and posttest questions.

## CONCLUSION

Based on the results of the analysis of research data and discussions that have been carried out regarding the integrated Problem-Based Learning (PBL) model of Education for Sustainable Development (ESD) to improve the problem-solving skills of class X students, it can be concluded that follows: 1. ESD integrated model learning (PBL) activities to improve the solving skills of class X students were carried out with an average percentage of 95.55% in the very good category. 2. Application of ESD integrated PBL learning model can improve students' problem-solving skills. This is indicated by 1) the results obtained from the posttest scores are higher than the pretest results with an N-Gain of 0.78 in the high category, while in the control class, the N-Gain results obtained were 0.67 in the medium category 2) post results -test for both classes in the independent test is 0.162, which means the significant value is greater than 0.05, so H1 is accepted. So, there is a significant difference in the average of the post-test scores for the experimental class and the post-test for the control class. 3. Students' responses to the implementation of the ESD-integrated PBL learning model to improve students' problem-solving skills based on analysis of the response questionnaire obtained positive responses in class with an average percentage above 70%, which means the points on the student response questionnaire were in a good category.

Based on the research that has been conducted, there are several stages carried out in collecting research data by the design that has been studied. The following are some findings that are used as advantages and disadvantages of this study: a) Advantage:

1. There are several interesting reference sources to be used as research materials and reinforcement in conducting this research.
2. Innovation in this study in the form of a greenhouse pyramid has not been widely studied, making this research more interesting to study.
3. In the field study, it was seen that students were enthusiastic about the ongoing learning and made physics interesting to learn.
4. There is good coordination between schools, researchers, teachers at schools, and students to be able to complete this research completely.

b) Disadvantages: 1. Less than optimal time allocation in learning. 2. Students who have never done physics practicums at school need to be given an initial introduction to the stages of conducting practicums so that they require longer practicum times.

## SUGGESTION

Conducting practicum and learning activities for a longer period. The innovation in this research in the form of the greenhouse limas has not yet been widely studied, making this research more interesting to research. The findings of recommendations in further research discuss materials and tools that can be used as environmentally friendly greenhouse limas so that they can improve the salt production process to produce quality salt and can also discuss the effects of weather changes during the dry and rainy seasons during the salt production process.

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