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The Influence of Problem-Based Explorative Learning Model (PEM) in Increasing Students' Ability to Create Solutions to Environmental Problems

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Abstract

Learning about environmental issues has not been carried out well, the environment around the school is not utilized optimally. Problems in the environment around the school can be used as a learning resource to improve students' thinking abilities in creating solutions. Students gain meaningful learning experiences through problem-based exploratory learning in the environment around the school. The research aims to analyze the effect of applying the Problem-based Explorative Learning Model (PEM) in learning environmental problems on increasing students' ability to create solutions. This research uses a pre-experimental design, one group pretest-posttest design. Samples were taken using random sampling technique. Data was collected through observation sheet instruments, essay test questions, student response reflection journals and biology teacher responses. The effect of the PEM model was measured using the Paired Sample T-test with a Sig (2-tailed) value of 0.000 <0.05 and an N-gain score indicating a Sig value. 0.76>0.7. The results show that there are differences in pretest-posttest scores on the variable ability to create solutions and a significant influence on the application of the PEM Model in learning environmental problems. Achievement of the Ability to Create Solutions (KMS) indicator shows an average score of 82%. The implementation of the PEM Model syntax was measured using a student response instrument with an average score of 87% and a biology teacher response instrument with an average score of 94%. The implementation of learning using the PEM Model was very good. In conclusion, the PEM model has a significant effect in increasing students' ability to create solutions to learning environmental problems.

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INTRODUCTION

Biology is a branch of science with the characteristic of using nature and the surrounding environment as an object of study for learning resources so that it must interact directly with nature in the learning process (Alimah & Marianti, 2016). In line with learning environmental problems that use the surrounding environment as a learning resource. Learning environmental problems requires real objects and subjects at each stage of the activity to support the process of solving problems and creating solutions related to the phenomena found.

The topic of environmental problems is a complex topic and has a wide reach. This requires students to be able to interact directly with the objects to be studied. However, in reality, the current implementation of biology learning has not met expectations. Implementation in learning activities, teachers only distribute topic notes and rarely hold practice questions which results in students' low critical thinking abilities in solving problems. Apart from that, the phenomenon that occurs in the field is that the majority of teachers use teacher-centered lecture methods and do not utilize learning media (Sulistyo & Ismarti, 2021).

Biology learning based on environmental problems integrates biological concepts with understanding and solutions to environmental problem phenomena. Environmental problem-based learning can encourage students' awareness of environmental sustainability and equip students with the knowledge and skills needed to analyze, evaluate and create solutions to environmental problems. Knowledge about pollution can influence critical thinking so that students are more motivated to solve environmental problems (Munawar et al., 2019). The knowledge gained can make students environmentally aware, thereby creating solutions to problem solving (Antika et al., 2021).

According to (Makrufi et al., 2016) the ability to solve problems and create solutions is an individual's ability to think through collecting data and facts, the process of analyzing information and preparing effective alternative steps to solve problems. The ability to create solutions (KMS) is one of the competencies launched to support 21st century learning. The ability to create solutions (KMS) can be said to be influential if it meets the indicator aspects of the ability to create solutions, namely analyzing, evaluating and creating. Considering the above phenomena, to achieve meaningful, effective and efficient learning, a learning model is needed that has the right approach and strategy.

Edgar Dale developed the cone theory of experience which states that the more concrete the learning materials and resources, the more experience students will gain. Mantek et al., (2019) have conducted research which aims to determine the effect of learning using the Problem Based Learning (PBL) model which utilizes environmental learning resource media on the topic of environmental problems on increasing students' mastery of concepts. The results of this research show that the application of learning using the Problem Based Learning (PBL) model is able to improve student learning outcomes. The characteristics of the Problem Based Learning (PBL) model are that it requires students to solve problems and produce work or ideas that represent a form of creating solutions to the problem phenomena found (Nurhadi, 2019).

Apart from the advantages of the Problem Based Learning (PBL) model, the weaknesses of PBL are: 1) Students will feel reluctant to try if they lose interest and do not have confidence that the problem being studied is difficult to solve; 2) Preparation requires quite a lot of time to achieve success in learning strategies through problem solving; 3) Students will not learn what they want to learn without an understanding that refers to the reasons why students are trying to solve the problem being studied (Erwanto, 2020). The PBL model will be optimal if combined with components of the JAS approach based on students centered. Students are facilitated to experience meaningful learning to improve their ability to create solutions to problems found during independent learning.

Optimization of the application of the PBL model will be achieved if problems and problem solving are combined through meaningful experience. Meaningful and enjoyable learning experiences

are obtained from the Environmental Exploration approach. Students will have the opportunity to learn through the process of experiencing and discovering for themselves with the JAS approach which utilizes the natural surroundings (Kartika et al., 2013). The explanation above shows that it is necessary to integrate the Problem Based Learning (PBL) learning model and the Natural Exploration (JAS) approach in learning environmental problems.

The integration of the learning model is named the PEM Model. The PEM model is based on the Problem Based Learning (PBL) learning model which emphasizes learning activities on student activities to explore in real life in the environment to find solutions to problem solving, where the teacher only acts as a facilitator. The PEM learning model is an integration between the syntax of the Problem Based Learning (PBL) model and components of the Environmental Exploration (JAS) approach. Exploratory represents an emphasis on independent investigation and discovery by students through exploring the natural environment. Problem-based represents the application of problem-solving as the main tool to encourage learning so that students achieve the ultimate goal of being able to create solutions to the problems found.

The Problem-Based Explorative Learning Model (PEM) is an innovative approach to biology learning which is characterized by students being faced with a problem related to the natural surroundings and utilizing the surrounding environment as a learning resource. The PEM model uses the surrounding environment as a learning resource and uses real learning objects. Learning directly with the natural surroundings will be connected in that learning is carried out in a real way and will provide students with meaningful learning experiences (Ilhamdi et al., 2022). The combination of PBL learning syntax combined with JAS approach components will optimize the weaknesses of learning with the PBL model. The following is a description of the PEM Model syntax in Table 1.

Table 1. Integration of the JAS Approach and Problem Based Learning in the PEM Model

Syntax PBL	**JAS Components**	**Syntax PEM Model**	**Description**
Orientation	Exploratory, Constructivist	Orientation	Students find contextual ideas related to learning topics
Organization	Learning Communities Science Process, Bioedutainment	Organizing	Organizing students in groups
Guide		Mentoring	Students draft learning topics and solutions with teacher guidance
		Bioedutainment	Students carry out environmental exploration in the surrounding environment
Developing & Presenting Results		Development & Submission of Work	Students design solutions to problems related to topics based on the results of their environmental exploration
Analyze & Evaluate	Authentic Assesment	Analysis & Reflection	Students formulate learning conclusions and solutions related to learning topics

The ability to create solutions for students is emphasized in biology learning, including the topic of environmental problems. This can be achieved through the implementation of the Pancasila student profile in the form of student independence in identifying, analyzing and formulating creative solutions to biological problems in the surrounding environment. Below is a table of draft aspects of the Ability to Create Solutions indicators which are guided by the cognitive level of Bloom's

Taxonomy Revised in (Utari & Madya, 2011).

Table 2. Cognitive Aspects & Indicators of Ability to Create Solutions

Aspects of KMS	Indicators KMS Cognitive		
Analyzing (C4)	• Selecting	:	Selecting information that is considered to fit the topic criteria
	• Diagnose	:	estimate in detail a phenomenon
	• Attribute	:	conclude the causes and effects of phenomena
	• Compare	:	combine things to find out the differences
	• Identify	:	recognize the components and factors that influence a phenomenon
Evaluating (C5)	• Summing up	:	sets out an overview of several descriptions
	• Arguing	:	express an opinion on something based on facts to convince
	• Projecting	:	give an approximate idea of something
Creating (C6)	• Reconstruct	:	rebuild a new concept
	• Combine	:	combine several things
	• Designing	:	organize everything before acting
	• Create	:	produce a new solution that has never existed before

Learning environmental issues in the independent curriculum is not only focused on theoretical knowledge, but also emphasizes practice and direct experience. Utilizing the environment as a learning medium has several advantages, including (1) saving costs, (2) providing real experience to students, (3) because these objects come from the students' environment, these objects will be in accordance with their characteristics and needs. students, (4) lessons are more applicable, (5) provide direct experience to students, (6) more communicative (Erviana, 2015).

Environmental problems can be defined as disturbances in the balance of the ecosystem due to natural factors or human activities or environmental conditions that do not comply with established quality standards. Explanation of quality standards in Law no. 32 of 2009 Chapter I General Provisions Article 1 Paragraph 13, namely "Environmental quality standards are a measure of the limits or levels of living things, substances, energy or components that exist or must exist and pollutant elements whose existence is tolerated in a particular resource as an environmental element life." Legislation has regulated in Chapter X Rights, Obligations and Prohibitions Article 67 of Law no. 32 of 2009 concerning Environmental Protection and Management which states "Every person is obliged to maintain the sustainability of environmental functions and control environmental pollution and damage".

The environment around students can act as a rich and authentic learning resource for students to learn biological concepts. The environment acts as an interesting and interactive contextual learning medium to increase student motivation and participation in learning biology. Contextual learning is learning that links the study or subject being studied with real situations, so that there is a relationship between knowledge and its application in students' lives (Muhfahroyin & Santoso, 2022). Learning about environmental problems can be carried out well if students fulfill the requirements for understanding concepts related to community dynamics, namely interactions between populations in their habitat which is the basis for the balance of the environmental ecosystem.

The concept of community dynamics includes students' knowledge about ecosystem conditions in the surrounding environment, both natural resources and other environmental factors. This knowledge will encourage students to analyze in more detail the interactions between organisms

in an ecosystem and the life cycles of organisms that support the creation of environmental balance. The imbalance in the ecosystem environment that occurs can be caused by environmental problems, both naturally occurring and human activities.

Types of environmental problems can be categorized based on their impact, namely (1) Environmental pollution which includes water, air and land pollution. Environmental pollution can be caused by various factors, such as industrial waste, household waste, and greenhouse gas emissions. Environmental pollution can have a negative impact on human health, ecosystems and biodiversity. (2) Habitat damage can be caused by various factors, such as land conversion, over-exploitation of natural resources, and climate change. Habitat destruction can cause species loss and disrupt the balance of the ecosystem. (3) Climate change is caused by increased greenhouse gas emissions into the atmosphere. Climate change can cause various negative impacts, such as rising sea levels, increasing the intensity of extreme weather, and changes in rainfall patterns.

Environmental problems that occur in the environment around students will certainly have a crucial impact, these impacts can be in the form of (1) The impact on human health can cause various diseases, such as respiratory disease, heart disease and cancer. (2) The impact on the ecosystem in the form of habitat damage can cause the loss of species, disrupt the balance of the ecosystem, and reduce biodiversity. (3) Social and economic impacts can cause loss of livelihood, migration and social conflict. The explanation of the phenomenon of environmental problems and the impacts they cause will encourage students to be able to think about adaptation and mitigation efforts related to the real problems faced.

Adaptation is an effort to adjust to environmental changes caused by environmental problems such as pollution. Environmental pollution that causes problems can be prevented by mitigation efforts, the aim of which is to reduce the negative impact of environmental problems that may occur. The problem of environmental pollution is a source of topics for creating creative ideas for students regarding their knowledge in handling waste. Students discuss how to develop a series of efforts that can be made to resolve the environmental problem phenomena they find. Efforts launched can be in the form of waste processing, campaigns or outreach and work programs in the school environment in line with student creativity.

The design for creating solutions to environmental problems becomes the final output of students after exploratory learning activities in the environment around the school. Biology learning based on environmental problems is effective for improving students' 21st century skills, such as critical thinking, problem solving, communication and collaboration. Knowledge about pollution can influence critical thinking so that students are more motivated to solve environmental problems (Munawar et al., 2019). The knowledge gained can make students environmentally aware, thereby creating solutions to problem solving (Antika et al., 2021).

Based on the description above, the formulation of this research problem is: Does the PEM model have an effect on increasing the ability to create solutions to learning environmental problems?.

RESEARCH METHODS

Research activities will be carried out in the even semester of the 2023-2024 academic year. The type of research used is Quantitative Pre-Experimental design in the form of a one-group pretest-posttest design. The population used was class Samples were taken using random sampling technique. Data was collected using teacher observation assessment instruments, test questions, student response instruments and biology teacher responses. The test method is used to measure student learning outcomes cognitively on the topic of environmental problems in the form of essay questions. The test questions have been tested for validity, reliability, level of difficulty and distinguishing power of the questions. Test questions are given at the beginning as a pretest and at the end of the meeting as a posttest. The teacher observation assessment method is used to assess student activities in the learning

process. Learning was carried out in both experimental classes according to the PEM Model syntax.

For exploration activities, students are provided with E-LKPD which is used to guide activities in accordance with the syntax stages of the PEM Model. The observation assessment sheet used in this research aims to measure student activity in achieving learning outcomes in psychomotor and affective aspects according to indicators of the ability to create solutions. Analysis of research data in the form of student cognitive test results, teacher observation assessment results on psychomotor and affective aspects according to indicators of the ability to create solutions, results of student and biology teacher responses to the implementation of the PEM Model syntax in a quantitative descriptive manner. Assessment of increasing students' ability to create solutions is obtained through pretest and posttest essay questions as well as teacher observation assessment sheets. Biology subject student and teacher response instruments are used to measure the implementation of the PEM Model syntax during the implementation of learning activities. The effect of increasing the ability to create solutions was measured using the Paired Sample T-test and N-gain score test.

RESULTS AND DISCUSSION

Ability to Create Student Solutions

Students' ability to create solutions is measured using 6 (six) essay questions which have been adapted to indicators of the ability to create solutions at the cognitive level of Bloom's taxonomy C4-C6. The indicator aspect used aims to measure the ability to analyze, evaluate and be creative to create solutions to problems related to phenomena discovered during learning about environmental problems. Students who answer all the questions correctly and precisely will get a maximum score of 70 from each value weight on the various questions. The results of the Pretest and Posttest analysis of the ability to create solutions are presented in the following.

Table 3. Results of Descriptive Analysis of Ability to Create Solutions

Data	Class X.E-1		Class X.E-2	
	Pretest	***Posttest***	***Pretest***	***Posttest***
The highest score	44	91	64	100
Lowest Value	13	70	13	70
Average value	32	84	69	87
The number of students	34	34	35	35
KKTP Decree	70	70	70	70
Students Pass KKTP	0	28	0	30

Based on Table 3, it can be seen that the majority of students have not met the minimum completeness criteria during the pretest, this could be influenced by the students' lack of knowledge of the environment around them. Apart from that, the difference in biology learning hours could be a factor in students' low interest in learning. The results of the posttest given after treatment in the form of the PEM Model showed that students had met the achievement of learning objective criteria (KKTP) in biology learning on the topic of environmental problems.

The difference in pretest - posttest scores is supported by the results of the Paired Sample T-test analysis showing a 2-tailed significance value of less than 0.05, which means there is a difference in pretest and posttest scores, before being given treatment and after being given treatment. N-gain is used to measure the increase in students' ability to create solutions before and after learning activities using the PEM Model are implemented. The N-gain test was analyzed based on data from both experimental classes. The results of the N-gain score test which shows a g value> 0.7, namely 0.76 with an effectiveness percentage of 76%, can be concluded that the treatment given is in the high

category and is effective in providing an influence on students to be applied in biology learning environmental problems in order to improve their ability to create student solutions.

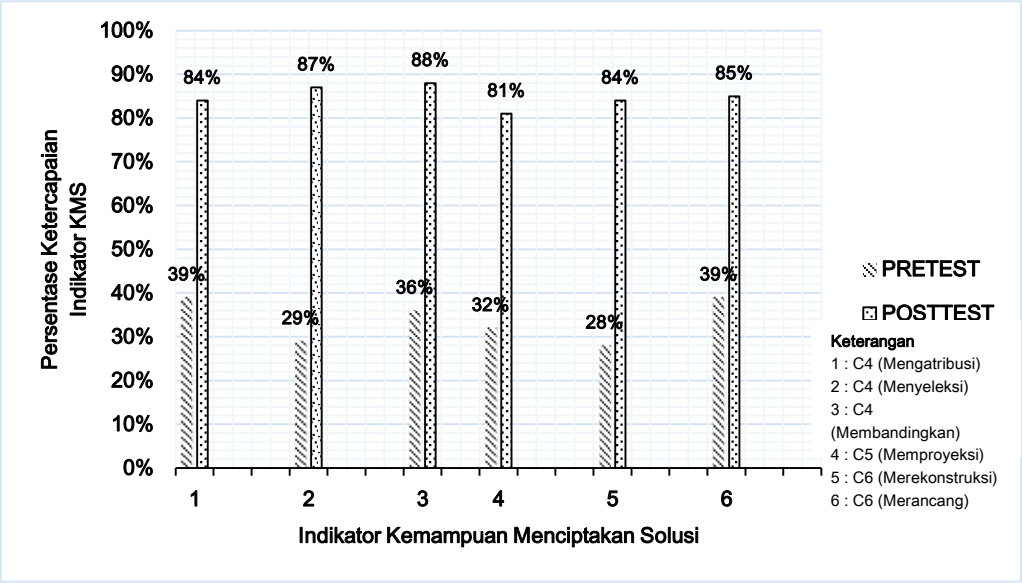

Figure 1. Achievement of Indicators of Ability to Create Solutions

Based on Figure 1, the teacher's observation assessment during learning activities shows that students have met the criteria for the ability to create solutions. Comparison of the average pretest-posttest scores on the ability to create solutions indicator showed a significant increase. The essay questions used as test instruments have met the requirements for cognitive level indicators C4-C6 in order to achieve an increase in students' ability to create solutions. The questions contain questions that refer students to directly observe the surrounding environment, so that the problems discussed are factual based on real learning sources.

Increasing students' ability to create solutions is shown in every cognitive aspect used. In the attribution aspect (C4 Analyzing), questions are presented about environmental problems in the form of air pollution that occurs around the school environment due to heavy vehicle activity. Students are asked to make attributions (analyze causes and effects) that might occur based on the environmental problem phenomena presented. The achievement of the attribution aspect showed a percentage of 39% in the pretest and a percentage of 84% in the posttest of all students' answers.

The selecting aspect (C4 Analyzing) presents questions about activities in the school laboratory that produce waste. Students are asked to analyze the types of B3 waste produced from biology laboratory activities at school and select the knowledge that students have to convey their arguments regarding the management of this waste. Achievement of the selecting aspect showed a percentage of 29% in the pretest and a percentage of 87% in the posttest of all students' answers.

The comparing aspect (C4 Analyzing) presents questions about case studies of plastic waste handling project activities that were found to be due to environmental pollution. Students are asked to compare the advantages and disadvantages of plastic waste recycling activities. The aim is for students to know the positive and negative impacts that waste processing may have on this

phenomenon. Achievement of the comparing aspect showed a percentage of 36% on the pretest and a percentage of 88% on the posttest of all students' answers.

The projecting aspect (C5 Evaluating) presents questions about environmental mitigation to reduce the negative impacts of environmental pollution problems. Students are asked to project a series of 10R prevention efforts and describe the benefits of the efforts implemented. The achievement of the student's projecting aspect showed a percentage of 32% in the pretest and a percentage of 81% in the posttest of all students' answers.

The reconstructing aspect (C6 Creating) presents questions about community dynamics related to the ecosystem in the student's surrounding environment. Students are asked to reconstruct their knowledge regarding mitigation and adaptation efforts for living things that would be carried out if conditions of weather change phenomena were presented. The achievement of the reconstructing aspect showed a percentage of 28% on the pretest and a percentage of 84% on the posttest of all students' answers.

The designing aspect (C6 Creating) presents questions about environmental phenomena around students who are exposed to environmental problems in the form of environmental pollution of water, air and land. Students are asked to express their knowledge in the form of ideas for solutions to problems of the phenomena they face which can then be implemented in real life. In addition, students are asked to convey the information they have regarding knowledge of concrete steps that have been taken by the school and students to overcome the phenomenon of environmental problems that occur around the school. Achievement of the design aspect showed a percentage of 39% on the pretest and a percentage of 85% on the posttest of all students' answers.

Problem solving is the highest stage in learning theory so that it will continue to improve students' abilities in solving every problem given (Rahayu et al., 2021). The achievement of the indicators of students' creative ability is seen based on an analysis of the number of students who answered the essay test questions correctly in the pretest-posttest. The students' pretest results showed that they had not achieved the creative indicators in the design aspect, because the answers filled in by the students did not meet the appropriate and correct categories.

Creativity indicators are placed in the questions by presenting case studies of school environmental conditions that are exposed to pollution. Students are asked to combine their knowledge and conceptual understanding to answer questions related to environmental mitigation efforts that might be made to deal with this phenomenon situation. Indicators evaluating the projecting aspect show better achievement, as evidenced by questions that present environmental mitigation. Students are asked to project mitigation efforts that can be carried out and the benefits of these activities for the environment.

Differences in indicator achievement can be seen based on students' pretest-posttest results and scores. Students' analytical skills, especially in selecting information, increased after implementing learning using the PEM Model, demonstrated by students' answers that answered correctly and precisely on questions that referred to students' knowledge regarding the B3 waste group found in the school biology laboratory. Exploration activities Exploring the Natural Environment (JAS) encourage students' ability to attribute environmental problem phenomena found in the surrounding environment.

Implementation of PEM Model Syntax in Learning Environmental Problems

The PEM model applied in class X biology learning on the topic of environmental problems has adapted to the independent curriculum-based learning guidelines. The topic of environmental problems is included in contextual learning. Contextual learning is suitable for use in realizing the

Pancasila student profile (Fauziah et al., 2022). This is in line with the Pancasila student profile which emphasizes critical reasoning, independence and creativity to support increasing students' ability to create solutions.

Table 4. Assessment of Achievement Indicators of Students' Solution-Creating Ability

KMS Indicator	Rating Poin			
	4	3	2	1
Able to invite fellow team members to discuss designing work on Environmental Problems		√		
Able to communicate using a structured train of thought in diagnosing a solution to a problem	√			
Have the ability to create newness based on the initial prerequisite knowledge they have	√			
Have a responsible attitude in identifying problems through new ideas orally or in writing	√			
Have the ability to project creative ideas practically and conceptually	√			
Have a critical thinking attitude in selecting all changes that occur in the surrounding environment	√			
Have the ability to analyze and evaluate factual evidence and problems that occur in the surrounding environment	√			
Have the ability to argue logically in solving problems in the surrounding environment	√			
Have the ability to organize, analyze and combine to solve a problem	√			
Have the ability to process and attribute information obtained through initial conclusions and test it through analysis with the support of literacy sources		√		
Able to make assessments and determine decisions by comparing effectively in processing data and using arguments	√			
Able to create solutions to various problems both by reconstructing general techniques and his own specific techniques	√			
Have a compromising attitude, be thorough and diligent in collaborating with other people to conclude problems in order to achieve a certain goal	√			

The PEM model is designed to activate students' abilities to analyze, evaluate and be creative by creating solutions to direct environmental problems found in the environment around students. Problems in learning environmental problems are always closely related to the daily life activities experienced by students, thus triggering the emergence of various questions. Khoirunnisa & Amidi (2022) stated that contextual problems can stimulate students to ask various questions from different points of view.

The PEM model was chosen to be applied to the topic of environmental problems because it is included in the contextual learning category which requires closer direct observation to analyze visible phenomena and the resulting impacts on students' daily lives. Contextual learning forms meaningful learning connections or meaningful relationships between real life and the material studied by students (Parhan, 2016). Learning activities using the PEM model utilize the environment around the school as a source of learning media objects. In this learning, what is used is the physical environment around the school.

The ability to create solutions (KMS) is said to be successfully achieved if it has fulfilled the Learning Goal Achievement Criteria (KKTP) which consists of cognitive indicators of analyzing, evaluating and creating. Each indicator is composed of aspects of ability that must be met by students.

The ability to create student solutions is achieved through five stages of the PEM Model syntax, namely: (1) Orientation, (2) Organizing, (3) Mentoring, (4) Bioedutainment, (5) Development & Submission of Work and (6) Analysis & Reflection. During learning activities on the topic of environmental problems, students are given E-LKPD as a medium for analyzing problem phenomena found in the surrounding environment, evaluating the conditions of environmental problems that occur and then creating appropriate problem solutions for the phenomena found.

In the first stage of Orientation syntax, the teacher introduces the environmental problems to be studied to students. The teacher gives pretest questions to find out students' initial knowledge about the learning topic to be studied, students are asked to work on them before continuing on to the next learning activity. The teacher gives an image based on the geography of the school environment which is located in the middle of the city, on the edge of the main road and is still surrounded by various types of trees at the back of the school building. The teacher gives examples of various activities carried out by students and school residents in their daily lives in the school environment. The aim is to attract students' attention and bring students into a real learning atmosphere. Such socioscientific issues can be used as study material in the learning process (Zeidler, 2009).

Teachers stimulate students' knowledge through brainstorming activities by asking questions such as "What types of environmental problems can be observed and often occur in daily activities in the school environment?" Then students are given the opportunity by the teacher to answer based on their opinions and points of view. Most of the students' answers referred to pollution problems that occurred in the school environment, including water, land and air pollution. Some students attributed pollution to human activity, while others answered it was a natural phenomenon. By discussing problems related to everyday phenomena during the learning process, you can train to develop problem-solving abilities, such as the ability to identify factors that cause problems to arise, carry out literature studies related to problems, and the ability to determine alternative solutions to problem solving (Saptono & Mubarok, 2021).

The second stage is Organizing syntax, in this stage the teacher invites students to form groups and divide assignments between the leader and group members. The teacher distributes E-LKPD as a media to guide activities at the next learning stage. Student Worksheets (LKPD) are learning resources that change the teacher-centered paradigm to student-centered, allowing students to be more actively involved in learning (Anggraini et al., 2016). The teacher ensures that all students understand the flow of learning activities to explore the surrounding nature based on the E-LKPD guidelines. E-LKPD presents activity steps starting from preparation, exploring the surrounding nature, discussion, analysis and presentation. E-LKPD work is carried out using the Bioedutainment learning syntax.

In the preparatory activities, students are asked to form discussion groups with an adjusted number of members and distribute tasks. Next, students are directed to carry out environmental exploration activities in the environment around the school to observe the phenomenon of environmental pollution. The exploration is carried out in groups spread across all corners of the school, then students record important things found during the exploration activities. The important thing that students need to note is only the answers to the questions presented in the discussion flow such as "What are the environmental conditions observed? Is there anything that triggers pollution?" as well as other questions that guide students to design schemes for creating solutions to problems. Students are asked to evaluate the activities carried out and present the results of the exploration with the teacher and other groups. Group discussion presentations are an important factor in creating a closer discussion atmosphere between group members, thereby supporting students in developing ideas in an effort to create solutions to environmental problems. Discussion is a form of speech activity that supports students to expand their knowledge and gain a lot of experience (Hernawati & Amin, 2017).

The third stage of Guidance syntax, at this stage the teacher directs students to re-confirm student answers resulting from brainstorming to avoid misconceptions during the implementation of the lesson. Next, each student, both individually and in groups, begins to discuss the topic that will be

discussed. The teacher plays a role in guiding and explaining what stages of learning will be carried out next. Students are ensured to understand what must be done, and the learning outcomes that must be produced. Learning activities are monitored directly to provide maximum guidance to each individual student. It is ensured that student groups regularly analyze environmental conditions around the school in different locations, to produce a wealth of information at the activity evaluation stage.

The fourth stage of Bioedutainment syntax, this stage is the core activity carried out by students. This bioedutainment provides students with the opportunity to explore the surrounding nature in the school environment. Students are asked to explore outside the classroom to be able to directly observe phenomena that occur in the surrounding environment related to environmental problems. Students in groups explore the natural surroundings to various corners of the school to observe different components. Locations around the school that were used as objects of observation for groups of students were: laboratory rooms, canteens, places of worship, parking lots, the front porch of the school by the main road, the front yard of the classroom and other corners of places that are often used as places for student activities.

The activity of exploring the surrounding nature at this stage is guided by the activity stages and discussion question references that have been listed on the E-LKPD. Each student is required to fill in the results of exploration observations and activity documentation after completing the activity. The implementation of activities is monitored directly by the teacher in each group to ensure that no students feel they do not understand and do not discuss with their group members. During exploration activities, students must fill in the E-LKPD according to what they find independently. This activity resulted in the answer that waste pollution was found in the school environment at certain locations, but others stated that the school was free from pollution and environmental problems. The differences in answers that were then discussed together through discussion presentation analysis activities.

Soil pollution caused by organic and inorganic waste is often found in corners of school canteens and classroom terraces. Air and noise pollution was found in the corner of the front veranda on the side of the school road adjacent to the classroom. The pollution was caused by general vehicle activity and vehicle exhaust that did not meet standards. Some students answered that there was water pollution around places of worship near the canteen due to drainage pipes not being arranged properly, causing unpleasant odors and standing water. Another answer refers to the condition of the waste bins which do not meet the sorting criteria, thus concluding that waste processing has not been carried out properly and the lack of awareness of the school community is the trigger for pollution.

The fifth stage of the Syntax for Development and Submission of Work, this stage requires students to design ideas, thoughts or works that can become innovations based on the needs of problem phenomena found in the surrounding environment. The design of this solution is based on the results of the students' direct exploration of the natural surroundings. The guidelines and questions presented in the E-LKPD have guided students to write a draft solution to the problem that will be implemented. The design of students' ideas or work begins with writing down the ideas then continues with details of the work/ideas that will be implemented. After that, at the next meeting, students were asked to present draft work related to environmental pollution problems and proposed solutions.

The design of problem solution ideas begins with expressing each student's ideas in a class discussion with the teacher and group members. Students are directed to create solutions to the environmental problems they find. Creating solutions to students' problems mostly takes the form of processing and handling waste due to pollution, both organic and inorganic waste, so that it becomes a product that is efficient and has economic value. The construction of a school garden was the design idea chosen by students who observed the entire school environment, the reason being to provide a special location for the ecosystem community which consists of various types of plants and animal organisms around the school.

Students who are active in school organizations initiated environmental awareness campaign and outreach programs involving school residents as an effort to mitigate environmental pollution.

Apart from that, students initiated the procurement of environmentally friendly trash cans so that environmental pollution which is considered trivial does not have a greater negative impact. All students' draft ideas for creating solutions are published using social media and class presentations. This activity is an effort to support students' communication skills in conveying opinions to the public (Prastiwi et al., 2020).

The sixth stage of Analysis & Reflection syntax, the teacher gives posttest questions to determine students' understanding after implementing the lesson. The posttest and the results of ideas for creating solutions are used as authentic assessments. Authentic assessment (Authentic Assessment) is a significant measurement of student learning outcomes in the realm of attitudes, abilities and knowledge (Herianto & Indana, 2020). At the end of the lesson, students and the teacher discuss together and conclude the learning activities that have been carried out, emphasizing the concepts that each student must understand. Important concepts emphasized are related to environmental pollution, waste handling, community dynamics, adaptation and mitigation of environmental problems. Students respond by conveying things they do not understand to be discussed together.

In the final stage, students are directed to analyze what activities have been carried out and reflect through learning reflection journals on environmental problems that have been provided by the teacher. Students are given the opportunity to fill in a reflection journal to be able to express what they have learned, what they don't understand and what they want to experience in future learning activities. In the reflection journal questionnaire, students are given the opportunity to provide input and assessment suggestions to teaching teachers for better teaching improvements in the future.

Student Responses to the Implementation of the PEM Model

Student responses were measured using a questionnaire instrument containing 19 learning implementation statements and 6 questions related to student reflection. The questionnaire was filled in by 21 student respondents from both experimental classes or 30% of the total population. The results of student responses were then analyzed using quantitative descriptive analysis of percentages (%). Data analysis of student responses to the implementation of learning shows a score of 87%. It can be concluded that learning biology about environmental problems using the PEM model can encourage students to analyze, evaluate and be creative in achieving increased ability to create solutions.

Table 5. Student Responses to the PEM Model in Learning Environmental Problems in Increasing the Ability to Create Solutions.

No	Description	S dan SS		STS dan TS	
		Resp	Result (%)	Resp	Result (%)
1	I participate more actively in group discussions to find solutions to environmental problems.	17	80	4	20
2	I am interested in the learning approach used by teachers to teach the topic of environmental problems.	21	100	0	0
3	Through studying biology, I am motivated to observe and identify further various environmental problem phenomena that occur in the environment around me.	16	76	5	24
4	As an effort to solve environmental problems during biology learning, my peers and I were inspired to design problem-solving solutions.	21	100	0	0
5	With the biology learning approach used by the teacher, I can be interactive in conveying arguments during the learning process.	20	95	1	5
6	The teacher gave me the opportunity to reflect on the learning that had been done to improve reconstructing my understanding of the concept.	21	100	0	0
	Average	**87%**		**13%**	

Information
S : Agree
SS : Strongly agree
TS : Don't agree
STS : Strongly Disagree
Responden : Biology Teacher

The results of the descriptive percentage analysis show a significant increase in the two experimental classes in the indicator aspect of students' ability to create solutions in analyzing, evaluating and creating. Increased students' ability to create solutions because various learning strategies have been implemented, such as the implementation of integrated Problem Based Learning which prioritizes final skills in the form of problem solving and the environment around students as a learning resource. This research applies the integration of the PBL model and the Environmental Exploration Approach (JAS). Based on the summary of these results, it can be seen that the application of the PEM Model can help students analyze problem phenomena in environmental learning resources in learning environmental problems, evaluate essential concepts that students must understand, and create their ideas in the form of creating work designs in the form of solutions to problem phenomena. which he discovered during the Environmental Exploration (JAS) learning activity that had been carried out previously.

Teacher Responses on the Implementation of the PEM Model

Teacher responses were taken using non-test instruments in the form of questionnaires. The questionnaire was filled out by a class X biology teacher at SMAN 12 Semarang who taught the research experiment sample class. The teacher's response is important in supporting research, because before being applied to the experimental class it requires approval from the teacher because school teachers have more experience and knowledge about the characteristics of students in each group and individual. Questionnaire responses from biology teachers will be used as a reference for improvement if the instrument is declared less suitable for measuring student ability indicators.

Table 6. Teacher Responses to the PEM Model in Learning Environmental Problems in Increasing the Ability to Create Solutions.

No	Description	TT	KT	T	ST
1	Teachers encourage students to think critically in creating solutions through brainstorming	0	0	0	100
2	The teacher ensures that each student understands their assignment and role in the group, and encourages students to discuss and help each other in completing assignments.	0	0	0	100
3	The teacher walks around the classroom to observe and guide students during learning.	0	0	100	0
4	Teachers use real and interactive media and learning resources.	0	0	100	0
5	The teacher assesses the work and presentation of each group objectively, and provides useful feedback to improve further learning.	0	0	0	100
6	Students independently reflect on their learning, by identifying what they have learned, how they learned it, and what they can do to improve their learning in the future.	0	0	100	0
	Average			**100%**	

Information

TT : Not Implemented
KT : Less Implemented
T : Done
ST : Very Executed
Responden : Biology Teacher

Based on Table 6, the results of the teacher's responses regarding the implementation of Environmental Problems learning using the PEM Model have been implemented according to a series of syntaxes and have had a positive impact on students' ability to analyze, evaluate and create in order to improve students' ability to create solutions. Teacher response data is needed in preparing research instruments, such as student test instruments. Table 7 presents data on the results of teacher responses to the student treatment test instrument in learning environmental problems to improve students' ability to create solutions.

Table 7. Teacher Responses to the PEM Model Instrument for Learning Environmental Issues in Improving Capabilities Create Solutions.

No	Description	STS	TS	S	SS
1	The instrument tests the ability to create solutions related to learning Environmental Problems	0	0	0	100
2	The instrument for testing the ability to create solutions is included in the category of contextual instruments	0	0	0	100
3	The indicators on the test instrument for the ability to create solutions are in accordance with the parameters of the problem solving and solution creation aspects	0	0	0	100
4	The scope of discussion in the test instrument for the ability to create solutions is integrated with Learning Achievements and the Flow of Learning Objectives	0	0	100	0
5	The scope of discussion in the test instrument for the ability to create solutions is integrated with the achievements of the Pancasila Student Profile who are independent, responsible and creative	0	0	100	0
6	Questions on the test instrument for the ability to create solutions train students' skills in analyzing, evaluating and creating concepts on the topic of Environmental Problems	0	0	0	100
7	Biology teachers can apply this test instrument to measure students' ability to create solutions	0	0	100	0
8	The test instrument for the ability to create solutions can provide reflection for teachers regarding follow-up teaching on students' ability to create solutions	0	0	100	0
	Average	0%		100%	

Information

S : Agree
SS : Strongly agree
TS : Don't agree
STS : Strongly Disagree
Responden : Biology Teacher

Based on the questionnaire that has been filled in, the teacher agrees that this model is easy to apply, flexible and appropriate to be applied to learning environmental problems. Biology teachers have agreed that this learning model has an influence in the form of increasing the ability to create solutions in learning through student participation in discussions, this can improve students' ability to create solutions. The PEM model was declared well implemented based on questionnaire answers which showed that the assessment was highly implemented and implemented. The answer option is very applicable if each syntax and activity flow is implemented well and produces appropriate output. The implemented answer option is used if each PEM Model syntax is implemented according to the flow, but planned updates are inserted to suit the conditions during the implementation of learning activities.

The test instrument requires teacher responses because this research uses Bloom C4-C6 cognitive taxonomy levels. The ability to create student solutions requires a fairly high cognitive level to be able to meet the indicators applied in this research. The test instrument given as a tool for measuring the ability to create solutions, students are declared to be in accordance with learning environmental problems. This approval questionnaire states that the test instrument is in accordance with the indicators, learning objectives, learning syntax and has a contextual nature with language that is easy to understand and can help teachers carry out evaluations and reflections to improve students' solution-creating skills on the next topic.

CONCLUSION

Based on the results of the research that has been carried out, it can be concluded that the application of the PEM Model in learning environmental problems has an effective effect in increasing the ability to create solutions for class X students at SMAN 12 Semarang. The author hopes that this research can be used as an effort to enrich the various types of learning models and methods in teaching biology. So that further research can be carried out on other biology learning topics.

GRATITUDE

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