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Enhancing Environmental Awareness: Evaluating the Impact of Project-Based Hybrid Learning on Critical Thinking for High School Students

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ABSTRACT

Environmental education plays a crucial role in developing students' critical awareness, yet effective learning approaches remain a challenge in high schools. This study examines the impact of the Project Based Hybrid Learning (PJBHL) model on developing critical environmental awareness among high school students. The research utilized a quasi-experimental design and included a sample of 66 students from the State Islamic Senior High School (MAN) 5 Jombang, Indonesia. The experimental group engaged in a PJBHL model focused on creating products from recycled plastic materials, while the control group used traditional methods. Data was collected through pre-test and post-test questionnaires evaluating critical environmental awareness. Results from independent T-tests and N-Gain analysis revealed that the PJBHL model significantly enhanced students' critical environmental awareness compared to conventional methods. The experimental group showed an increase in all sub-indicators of environmental awareness, with environmental ethics achieving the highest score. The study suggests that the PJBHL model is an effective technique for promoting critical environmental awareness among high school students. This finding offers insights for teachers to enhance environmental education and encourage sustainable activities in high schools.

1. INTRODUCTION

The environment encompasses all entities, both tangible and intangible, that have an influence on and are influenced by human beings [1, 2]. Positive and negative human behavior towards the environment based on human knowledge and actions [3, 4]. Environmental awareness is an essential requirement for the study of environmental pollution prevention and the acceptance of eco-friendly attitudes, yet, it alone is insufficient [5]. Environmental pollution can be prevented through community participation [6]. Community environmental awareness, as defined by [7] is the collective perception of changes in both the environmental and socioeconomic aspects of a nation within a particular period and location. Addressing environmental issues is challenging without the active involvement and adoption of positive behaviors by individuals and communities [8]. Individuals that have environmental awareness are individuals who consciously select the most optimal approaches and techniques for the preservation of the environment during their daily activities, such as production and consumption [9, 10].

Developing critical thinking skills is crucial in studying the environment, as students' understanding of the environment are not only determined by their knowledge mastery [11]. Students in the academic community are expected to actively protect and maintain the environment, as well as find solutions to environmental issues, in order to foster a positive environmental attitude within themselves [12, 13]. However, in actuality, the majority of students lacked awareness of the schooling environment [14, 15]. A lack of understanding of the environment may hinder students' critical thinking and their awareness for the environment [16, 17].

Critical thinking skills are not only utilized in the process of acquiring knowledge, but also demonstrated through environmental care attitude [18]. Every day, the application of critical thinking abilities is crucial for ensuring environmental sustainability [19]. An environmental care attitude is not only concerned with abstract ideas, but rather with the practical application of critical thinking to ensure the preservation of the environment for both current and future generations [20]. The application of critical thinking abilities can be utilized to promote an attitude of environmental care [21]. This attitude or character is expressed not just in terms of its philosophical meaning, but also in terms of its contextual meaning.

A fundamental approach to environmental awareness is crucial while studying geography. This attitude is referred to as critical environmental awareness [19]. It is crucial to cultivate this attitude among high school students to effectively address the increasing environmental problems and enable them to succeed as future leaders who actively work in conserving and rehabilitating the environment. Critical environmental awareness is needed to foster environmental care attitudes and behaviors, especially for school students. Environmental awareness is important for students to have an environmentally caring attitude and maintain environmental sustainability. Critical thinking is needed to have

environmental knowledge so that they are critical of environmental problems and management [22]. Environmental awareness is the knowledge, attitude and skills in dealing with environmental problems [23]. Critical environmental awareness can increase environmental knowledge through environmental education by providing insight into global and local issues concerning the environment. This enables a comprehensive and relevant education.

The findings from the environmental awareness observations indicate that the attitudes and level of awareness among students at State Islamic Senior High School (MAN) 5 Jombang, Indonesia, about the environment are relatively low. They have a low expectation for the school environment and messy classrooms since they believe that the responsibility of clearing up trash lies with the cleaning staff. This issue is ironic because students have learned about the use of sustainable principles in using natural resources.

It is necessary to incorporate environmental education into learning in order to promote a more critical attitude towards environmental awareness [24]. Learning activities that are good and effective will assist students in fulfilling their needs [25]. Teachers who serve as mediators have the ability to decide on the types of activities and learning models that are used to achieve learning goals and enhance the effectiveness of learning [26]. The achievement of learning objectives and the effectiveness of the learning process are demonstrated through learning outcomes, which encompass the evaluation of students' acquired attitudes, knowledge, and skills. Selecting a suitable teaching method based on the given topic can facilitate students in achieving the best potential learning results [27]. On the other hand, if the selected learning model does not align with the material and learning goals, the students' learning outcomes will be not optimal.

The quality of education is influenced by more than just the extent of students' learning outcomes [28, 29]. Learning is considered to be of high quality when it enables students to develop the skills and knowledge needed to successfully compete in the workplace when they graduate [30]. Competent individuals are those that possess a mastery of various life skills and thinking skills. Hence, the learning process is anticipated to enhance the thinking skills of different students [31, 32].

Project learning, also referred to as PjBL, is an educational framework that can improve students' cognitive skills in 21st-century competences [33]. PjBL entails facilitating students' active and autonomous participation in the learning process while enhancing their abilities to cooperate and communicate with peers [34]. Project-Based Learning (PjBL) is considered an effective pedagogical approach for students pursuing scientific studies [35]. PjBL positively influences learning outcomes [36], enhances creative thinking abilities, fosters critical thinking skills [37], and boosts student motivation [35].

Several research have been conducted to analyze the influence of Project-based Learning (PjBL). However, the modification of learning activities in PjBL remains seldom. Other research has tried to integrate PjBL with different learning models, for instance, integrating PjBL with a blended learning system has been found to enhance 21st century abilities during the COVID-19 pandemic [38]. Studies on integrated PjBL with a hybrid design still need to be developed, based on the present hybrid learning trend [39]. The use of PjBL with a blended learning system in this study resulted in a significant improvement in students' engagement and enthusiasm in learning chemistry, leading to a more meaningful and enjoyable learning experience.

Further investigation is required to assess the benefits of incorporating Hybrid based Project-based Learning (PjBL) into the educational process, particularly to understand its effects across various criteria. The prior analysis solely focused on assessing the influence of PjBL through various methods on students' interest in learning. The examination of concept mastery, a crucial indicator intricately linked to learning quality, has yet to be performed within this educational framework. Furthermore, the enhancement of critical thinking abilities, a fundamental component of contemporary education, has yet to be undertaken. The study of character formation, an important aspect of the independent curriculum, has received less attention to this approach. Students must possess environmental awareness as one of their characteristics. Hence, this study conducted an investigation to evaluate individuals' critical attitudes and awareness regarding the environment. The primary objective of this study is to examine the impact of the Project Based Hybrid Learning (PjBHL) model on the development of Critical Environmental Awareness among high school students.

2. METHODS

This study used a quasi-experimental design known as the Nonrandomized Control Group Pretest Posttest Design. Its objective is to evaluate the impact of the Project Based Hybrid Learning Model on the level of Critical Environmental Awareness among high school students. The research was conducted during the second half of the 2022/2023 academic year, specifically from February to June 2023, in Jombang Regency, East Java. The variable being measured in this study is the attitude towards Critical Environmental Awareness. The independent variable in this study is the Project Based Hybrid Learning model. Purposive sampling technique was used in this study, by determining Madrasah Aliyah Negeri 5 Jombang East Java as the location of the study (refer to Figure 1). There were findings that based on observations some students were not yet critical of environmental awareness. This is evidenced by the classrooms that are still dirty when the learning process activities and plants in the school environment are not maintained.

(a) Class locations are not clean

(b) Plants in the school environment that are not well maintained

Figure 1. Observation results

Table 1. Differences in the syntax of the Project-Based Hybrid Learning (PJBHL) model (Conventional/Offline) and Project-Based Hybrid Learning (PJBHL) (Modification)

Project-Based Hybrid Learning (PJBHL) (Conventional/Offline) (George Lucas Educational Foundation, 2007)	Project-Based Hybrid Learning (PJBHL) (Modification)	
1 Creating topics with essential questions	1 Determine project topic	Online and Offline
2 Planning rules	2 Determine rules	Offline and Online
3 Making activity schedules	3 Make schedule	Online and Offline
4 Monitoring project progress	4 Monitoring	Online and Field
5 Evaluating work results	5 Assessment	Offline
6 Evaluation	6 Evaluation	Online
	7 Actualization	Field

Table 2. Syntax description of the Project-Based Hybrid Learning (PJBHL) model

No.	Stages	Activities	Description
1	Determine project topic	Taking a topic that is in line with real world reality and starting with an in-depth investigation.	Online and Offline
2	Determine rules	Determining the rules of the game, selecting activities that can support answering essential questions by integrating as many subjects as possible, and knowing the tools and materials that can be accessed to help complete the project.	Online and Offline
3	Make schedule	Educators and students collaboratively create a schedule of activities to complete the project. This schedule is created to find out how long it will take to complete the project.	Online and Offline
4	Monitoring	Educators are responsible for monitoring student activities during project completion. Monitoring is done by facilitating students in each process.	Online and Field
5	Assessment	Measuring the achievement of standards, playing a role in evaluating the progress of each student, and providing feedback on the level of understanding that students have achieved.	Offline
6	Evaluation	Educators and students reflect on the activities and results of the project that has been carried out. The reflection process is carried out both individually and in groups. At this stage, students are asked to express their feelings and experiences while completing the project.	Online
7	Actualization	Students take action in the environment to carry out actualization.	Field

Students from class XI of the Social Sciences Class of State Islamic Senior High School (MAN) 5 Jombang totaling 66 students were used as the population in this study. Class selection is based on student learning outcomes. Experimental classes are determined based on learning outcomes that are still below the minimum passing limit while control classes are determined based on learning outcomes above the minimum passing limit. The research sample comprised of students from class XI IIS 1 (control group) and class XI IIS 3 (experimental group) in the subject of Geography. Each class consisted of 33 students. In the control group, students engaged in learning through lectures, class discussions, and individual assignments. In contrast, the experimental group used the Project Based Hybrid Learning model as learning approach. During the experiment, students had four offline meetings and three meetings of online learning. Learning activities using the modified Project-Based Hybrid Learning (PJBHL) model can be explained in the Table 1.

The syntax modification in the development of the modified Project-Based Hybrid Learning (PJBHL) model refers to the George Lucas Educational Foundation (2007) [40, 41]. The syntax description of the PjBHL model resulting from this development is presented in the Table 2.

The Project-Based Hybrid Learning (PJBHL) model can be replicated to other topic environments with several notes, including (1) in accordance with the existing syntax; (2) learning style will be a consideration when replicating this model, students with an auditory learning style will be less appropriate to use the Project-Based Hybrid Learning (PJBHL) model, because students with this learning style will find it easier to understand the material through lecture methods, discussions or listening to video recordings. Students with a kinesthetic learning style will be more appropriate to use the Project-Based Hybrid Learning (PJBHL) model because kinesthetic students will understand the material faster through activities and direct experiences. (3) lesson material; some abstract materials such as theories, concepts or ideas will be difficult to achieve using this model, while for concrete and contextual materials such as environmental pollution, waste processing, and reforestation it will be more appropriate to replicate this model.

Sustainable resource utilization is used as material in the learning process in two classes. Within the sub topic "Efforts to Overcome Environmental Problems," students who were taught using the PjBHL learning method engaged in project activities with the theme of "Creating products using recycled plastic materials." Data collection for each variable studied was conducted twice, specifically prior to (pretest) and following (posttest) the application of independent variables in both classes. A questionnaire was utilized as data collecting technique about environmental awareness. This questionnaire comprises 19 statements. The questionnaire employs a Likert scale that includes items with four types of response: 1) always; 2) often; 3) sometimes; and 4) never. The study's findings were examined utilizing the independent T test. Prior to conducting the T test, the research data received testing for validity and reliability.

The critical environmental awareness questionnaire was tested on 40 students to determine its validity and reliability. Pearson's correlation was determined as a reference for making decisions on the validity test, while Cronbach's alpha was used as a reference for determining decisions on the reliability test [42]. The analysis of the validity and reliability tests used SPSS software version Windows 22 with the basis for determining the r table value of 0.312. Based on the results of the analysis, there were findings that the validity test with Pearson correlation showed that the critical environmental awareness questionnaire was proven to have a valid value.

Cronbach's alpha analysis is used as a reliability test on the critical environmental awareness questionnaire with a Cronbach's alpha value > r table [43]. If Cronbach's alpha coefficient has a value of more than 0.60 then the questionnaire is declared reliable. Table 1 can be concluded that the indicators of critical environmental awareness have reliable data. This can be proven by the Cronbach's alpha value >r table=0.312 and the Cronbach's alpha reliability coefficient >0.60. Each indicator in the critical environmental awareness questionnaire has a reliable value and the Cronbach's alpha reliability coefficient is in the high category.

3. RESULTS AND DISCUSSION

3.1 Implementation Project-Based Hybrid Learning (PJBHL)

The activity started with the observation of students in the control group. The control group implemented learning activities utilizing discussion techniques, question and answer sessions, focusing on strategies to address environmental issues and efforts to mitigate environmental issues. The experimental group was divided into 6 groups through random assignment, with each group comprising 5 to 6 students. The activities carried out at each stage of the Project-Based Hybrid Learning (PJBHL) model are presented in Table 3.

The first stage in this learning model is to divide students into 6 groups, each group discusses to identify project topics according to the theme by determining the type of product, the topics chosen by each group must be different from other groups so that students find various ways to solve problems. The second stage is to determine the rules that must be obeyed by each student during the learning process, the teacher as a facilitator offers rules that will be agreed upon by all students. Next, students will choose the materials needed. The materials recommended by the teacher are inorganic materials that are prone to causing inorganic waste that is difficult to decompose such as plastic and glass. It is hoped that after doing this activity, students will have better critical thinking skills and find solutions to various problems about waste that have a negative impact on the environment. In the third stage, students compile the steps of activities and the time needed to carry out project activities (refer to Table 4).

Table 3. Validity and reliability of critical environmental awareness questionnaire

Indicator	Statement	P (2-Tails)	r	Cronbach's Alpha
Attitudes Towards the Environment	Q1. I feel very concerned about environmental protection.	0.000	0.795	1.043
	Q2. I am willing to reduce the use of single-use plastics in my daily life.	0.000	0.832	
	Q3. I feel that preserving natural resources is very important for our future.	0.000	0.554	
	Q4. I will support environmental initiatives such as reforestation and environmental cleanup campaigns.	0.000	0.771	
Awareness of Environmental Issues	Q5. I feel that environmental issues should be a priority in government policies.	0.000	0.830	0.832
	Q6. I have a good understanding of the impacts of climate change on the planet.	0.000	0.428	
	Q7. I know why biodiversity around the world is important.	0.000	0.821	
	Q8. I can explain how air pollution affects human health.	0.000	0.623	
	Q9. I know why reducing food waste is an important environmental action.	0.000	0.823	
Personal Environmental Action	Q10. I regularly recycle paper, plastic, and cans.	0.000	0.609	0.791
	Q11. I try to save energy by turning off electronic devices that are not in use.	0.000	0.784	
	Q12. I use public transportation or drive together to reduce greenhouse gas emissions.	0.000	0.726	
	Q13. I am active in reducing waste burning and helping to keep the environment around me clean.	0.000	0.651	
Social Awareness	Q14. I feel that environmental issues are our collective responsibility as a society.	0.000	0.806	0.789
	Q15. I believe that environmental inequality is a problem that must be eradicated.	0.000	0.785	
	Q16. I have participated in environmental activities or events with my friends or community.	0.000	0.767	
Environmental Ethics	Q17. I believe that we have a moral obligation to protect the environment for future generations.	0.000	0.700	0.763
	Q18. I agree that actions that damage the environment are unethical.	0.000	0.729	
	Q19. I feel that my ethics and values influence my attitude toward the environment.	0.000	0.776	

Table 4. Stages of student activities in the Project Based Hybrid Learning (PJBHL)

No.	Stages	Activities	Description
1	Determine project topic	Each group discusses to determine the chosen topic.	Online and Offline
2	Determine rules	Determine the rules of the game, select and determine the tools and materials to be used in project activities.	Online and Offline
3	Make schedule	Collaboration between teachers and students to create a schedule with the aim of completing the project.	Online and Offline
4	Monitoring	Students make products from plastic waste materials, teachers monitor students' work. Monitoring is done by facilitating students in each process.	Online and Field
5	Assessment	Students exhibit their work from the products they produce.	Offline
6	Evaluation	Reflection on activities that have been carried out by students regarding the project.	Online
7	Actualization	Environmental actualization activities were carried out by students by sorting plastic waste.	Field

The activity in the next stage is the monitoring stage. Student activities at this stage are collecting the materials needed to make the product, then together making the product according to the plan agreed upon by the group. This activity

improves the ability to think creatively, find innovative solutions and generate new ideas in solving problems. This activity also improves the ability to work with others, contribute to a team, and listen to other people's perspectives in achieving common goals. The teacher as a facilitator monitors each student's work by facilitating at each stage of the process. Group activities in making products are shown in the following Figure 2.

After the product making activity is completed, then in the next stage, namely assessment, each group exhibits the products they have produced. Students are required to respond to questions and provide explanations to visitors regarding the exhibited products. This includes discussing the reasons behind selecting the product, the objective of its creation, the procedural steps involved, and the advantages of the final product. This practice aims to enhance the ability to engage in verbal communication, including speaking, listening, and effectively expressing ideas and opinions to others. The product exhibition is shown in Figure 3.

Teachers and students reflect on the activities and results of the project that has been carried out. The reflection process is carried out both individually and in groups. At this evaluation stage, students are asked to express their feelings and experiences during the completion of the project. After the reflection is carried out, together with the teacher, actualization is carried out by reducing the use of single-use plastic materials and sorting plastic bottle waste so that it can be recycled. Environmental actualization activities can be seen in Figure 4.

Figure 2. Student activities during hybrid project learning

Figure 3. The exhibition of final product

Figure 4. Environmental actualization in Project-Based Hybrid Learning (PJBHL) by sorting plastic bottle waste

3.2 Evaluation of the Project Based Hybrid Learning (PJBHL) model on critical environmental awareness

This study uses t-test analysis to evaluate critical environmental awareness attitudes data. The questionnaire used implements the Likert Scale. The critical environmental awareness attitudes questionnaire was given to the control group and the experimental group. The data obtained are as shown in the following Table 5.

The research data on critical environmental awareness attitudes indicates that the mean score for the experimental group is 59.27, which is higher than the mean score of 51.6 for the control group. Furthermore, there is a difference in the score between the control group and the experimental group. The control group has a maximum score of 57, whereas the experimental group has a maximum score of 70, resulting in a difference of 13 points. The control group has a minimum score of 43, which is 11 points lower than the minimum score of the experimental group.

Based on the data from each sub indicator of critical environmental awareness, the results are as presented in Table 6.

Table 5. The summary data of control and experimental groups

Category	Critical Environmental Awareness Attitude	
	Control Group	Experimental Group
Total Students	33	33
Maximum Score	57	70
Minimum Score	43	54
Mean Score	51,06	59,27
Standard Deviation	3.73	4.44

Table 6. Sub-indicator test for critical environmental awareness

Indicator	Pretest	Posttest
Attitudes Towards the Environment	69,7	82,73
Awareness of Environmental Issues	69,51	77,46
Personal Environmental Action	69,13	71,4
Social Awareness	71,21	81,82
Environmental Ethics	74,75	83,59

In the experimental group, as shown in Table 2, the test results for each sub indicator showed an increase. The sub indicator with the highest score was environmental ethics, while the sub indicator with the lowest score was personal environmental action. In the indicator of attitude towards the environment, the results of the students' tests increased after learning. There is Edgar Dale's learning theory regarding learning experiences that are integrated into learning [44]. During the project, students collect inorganic materials in the form of plastic waste in their respective environments. Students will gain direct experience regarding the impact of plastic waste on the surrounding environment, so that they will increase their concern for the environment by reducing the use of single-use plastic materials in everyday life. Furthermore, it supports efforts to reduce single-use plastic materials to maintain environmental sustainability. This is in line with the findings of previous studies that through learning experiences, attitudes towards the environment can be formed [45]. In addition, learning experiences regarding environmental management will provide a stimulus for students to preserve the environment by reducing plastic waste [46, 47].

The post-test results on the Attitudes Towards the Environment indicator showed an increase, because the Project-Based Hybrid Learning (PJBHL) learning process integrates Bruner's learning theory regarding meaningful learning [48]. In this indicator, students are expected to have a good understanding of environmental problems and their impacts on everyday life. During the learning activities, students will gain knowledge about plastic waste such as beverage bottles and used plastic food containers which are difficult to decompose if disposed of carelessly and will cause soil pollution, further damaging soil fertility. Knowledge of plastic waste is given contextually which is obtained during the project activities and will raise students' awareness of environmental problems around them. This is in line with Bruner's theory regarding meaningful learning through direct experience gained by students in the learning process regarding plastic waste which is given contextually [49]. Furthermore, learning activities with a meaningful learning approach will run according to plan and creatively if students can construct their knowledge [50].

In the learning process with Project-Based Hybrid Learning (PJBHL) integrated with constructivism theory, it can increase the Personal Environmental Action indicator [51, 52]. Constructivist theory explains that knowledge is constructed by students by interacting with the environment through the learning process [53]. Students interact directly with the school environment through the implementation of Project-Based Hybrid Learning (PJBHL). Students collect plastic waste and utilize plastic waste to make more useful items. This is in line with the findings of previous studies that students better understand knowledge based on contextual and authentic experiences, which is also an explanation of constructivist theory [54].

Social awareness indicators emphasize a sense of responsibility for environmental issues that are developing in society. Such as the problem of plastic waste which is an issue discussed by researchers around the world [55]. In addition, the role and participation of the community in preserving the environment are indicators of environmental awareness. During the project activities, students together with their groups utilize plastic waste to be converted into more useful products, such as flower vases, wall hangings, decorative lamp holders and others. After the product is finished, students hold a work exhibition and at the same time convey an environmental campaign to visitors to the exhibition about how to preserve the environment through reuse, reduce and recycle.

Project-Based Hybrid Learning (PJBHL) is integrated with behaviorism theory, with the aim of forming social awareness and human behavior that cares about the environment. This is in line with student project activities that have been carried out regarding the use of plastic waste, where students gain direct experience and are expected to be remembered by students [6, 56]. Routines and habits that have been carried out will be embedded in students' memories, so that they will be carried out unconsciously and continuously [57]. Behaviorism theory is one of the effective educational methods to improve how to behave and act according to environmental norms [58].

Environmental ethics is an indicator that emphasizes a sense of moral obligation to protect the environment so that it remains sustainable. Learning using the Project-Based Hybrid Learning (PJBHL) model is integrated with Vygotsky's social constructivism. Projects carried out by students face the environment directly. This is in line with Vygotsky's social constructivism theory that students learn from the environment with the aim of making the material easier to understand [59]. There are previous findings that the focus of Vygotsky's learning theory is on social and environmental learning [60].

Environmental ethics include the principles, standards, and actions that relate to how students interact with and care for the environment. Similar to prior research, environmental ethics plays a crucial role in guiding human values [61], beliefs [62], principles [63], behaviors [64], and attitudes to ensure environmental sustainability [65]. The use of environmental ethics is associated with solving environmental issues [66]. This encompasses the responsibility and awareness of students toward the environment within their school facilities or in the surrounding areas of their homes. The score of each sub indicator of the experimental group is shown in the following Figure 5.

Respondents select items from each sub indicator. In the experimental group, the personal environmental action sub indicator has the lowest score. The sub indicator is shown in the following Table 7.

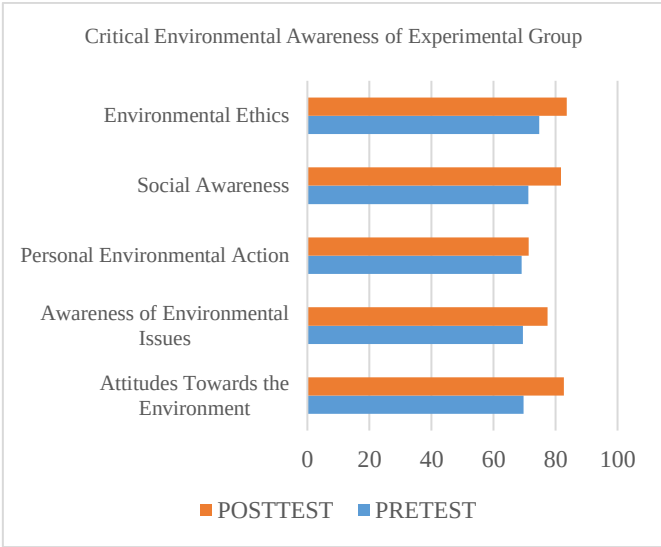

Figure 5. Sub indicator test for critical environmental awareness in the experimental group

Table 7. Sub indicator items for personal environmental action in the experimental class

Question Items	Personal Environmental Actions	PreTest	Post Test
10	Recycling	59,85	61,36
11	Saving Energy	72,27	81,06
12	Reducing Gas Emissions	69,7	71,97
13	Reducing Garbage Burning	69,18	72,73

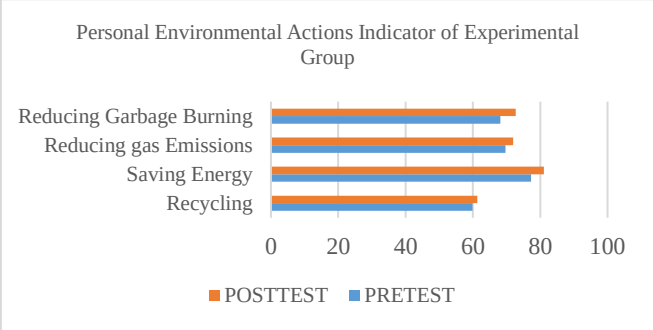

Figure 6. Sub indicator test for personal environmental action in the experimental group

Table 8. Sub indicator items for environmental ethics in the experimental group

Question Items	Environmental Ethics	PreTest	Post Test
17	Moral obligation to protect the environment	72,73	87,88
18	Engaging in activities that damage the environment is considered unethical	73,48	84,85
19	Personal ethics and values affect the environment	78,03	78,03

The minimum score among the sub indicators of personal environmental action is the recycling of products derived from plastic, paper, or cans. This indicates that students have a limited understanding in using non-biodegradable materials, such as plastic, in comparison to other objects. The result analysis of the item values on the sub indicator of personal environmental action is shown in Figure 6.

The sub indicator of environmental ethics has the highest score in critical environmental awareness. This sub indicator has three questions: first regarding the recognition of a moral duty to protect the environment, second about the belief that activities causing harm to the environment are immoral, and third exploring the influence of ethics and personal values on attitudes towards environmental sustainability. The question scores for this sub indicator are shown in Table 8.

The sub-indicator of environmental ethics is included in the high category due to the learning experience gained during the learning process. The learning experience gained by students about environmental damage by plastic waste, soil damage due to plastic waste, and the experience of overcoming these problems through reduce, namely reducing the use of single-use plastic bottles, recycling, by making crafts or other products from plastic bottle waste. This is in line with Edgare Dale's learning experience theory, which states that direct experience gained can help students understand and overcome problems regarding environmental damage due to plastic waste [44, 67]. The environmental actualization stage also plays a major role in the high value of environmental ethics, so that students sort used plastic bottles in a separate place, this is done every day, especially in their school environment. There are findings in previous studies that actualization activities can increase problem-solving skills and memory skills by up to 90%. The bottle sorting activity carried out every day will be indirectly carried out by students without being given direction, because it has been recorded in the students' memories [68].

According to the sub indicator of environmental ethics, respondents expressed a strong sense of moral obligation to protect and preserve the environment, as indicated by a post test score of 87.88. The sense of obligation to preserve the surrounding environment in order to ensure its sustainability will emerge when individuals perceive and recognize the importance of having and requiring good environmental conditions. Providing students the obligation to participate in maintaining and taking care of their surrounding environment fosters a sense of ownership and an awareness of the environment's importance [69, 70]. Engaging in pro-environmental acts contributes to the enhancement of sustainable environmental sustainability, which originates in environmental responsibility [71, 72]. Prior research has established a strong correlation between environmental education in schools and the sense of responsibility and morality towards environmental protection [73, 74]. Environmental education is a process that involves clarifying values and cognitive concepts to develop, understand, and appreciate skills and attitudes that are crucial for fostering mutually beneficial interactions between humans, cultures, creatures, and the environment [75-77]. The results of sub indicator item for environmental ethics are shown in the following Figure 7.

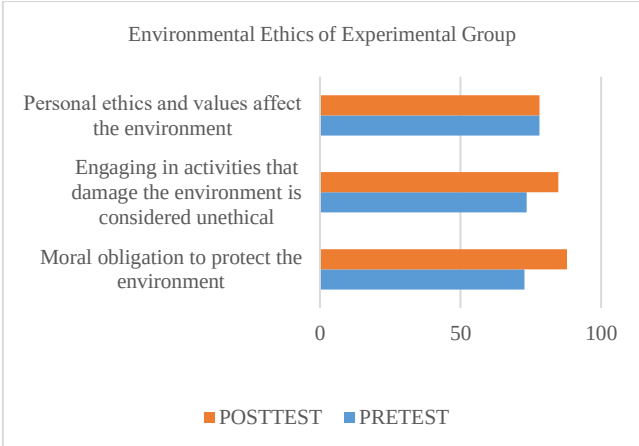

Figure 7. Sub-indicator test for environmental ethics in the experimental group

The N Gain calculation is used to evaluate the Project-Based Hybrid Learning model on critical environmental awareness attitudes. Quantitative analysis in the form of pre-test data taken before learning and post-test data taken after learning. The pre-test and post-test scores for both the control group and the experimental group are shown in Tables 9 and 10.

An independent t-test was conducted to determine the impact of the Project-Based Hybrid Learning model on critical environmental awareness. This test is conducted to compare the mean scores of two separate sample groups, specifically the control group and the experimental group. The results of this test are shown in Table 11.

Table 9. N Gain test for the control group

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Pretest	33	32	55	45.12	7.288
Posttest	33	45	58	52.36	3.587
NGain_Percentage	33	4.26	20.59	12.5478	5.21998
Valid N (listwise)	33				

Table 10. N Gain test for the experimental group

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Pretest	33	40	65	53.64	7.382
Posttest	33	53	70	60.21	4.114
NGain_Percentage	33	2.86	23.33	13.4158	5.41988
Valid N (listwise)	33				

Table 11. Independent sample t-test

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Critical Awareness	Equal Variances Assumed	0.653	0.422	-8.261	64	0.000	-7.848	0.950	-9.746	-5.951
	Equal Variances Not Assumed			-8.261	62.833	0.000	-7.848	0.950	-9.747	-5.950

Table 12. Average N Gain test in the experimental group and control group

No.	Group	Mean Score of N Gain
1	Control Group	0.24
2	Experimental Group	0.33

The data in Table 8 indicates that the significant value for the independent sample t-test is 0.000 or <0.05. The findings demonstrate a disparity in the enhancement of critical environmental awareness attitudes between the experimental group and the control group. Consequently, it can be deduced that participation in learning activities using the Project-Based Hybrid Learning paradigm significantly enhances critical environmental awareness attitudes.

According to the data provided, it can be concluded that the experimental group demonstrates higher levels of critical environmental awareness attitude in comparison to the control group. The increase reflects the model's effectiveness. In the experimental group, students collaborate in groups to create projects utilizing recycled materials, specifically plastic. Through engaging in such project activities, students will enhance their comprehension of various forms of waste and develop an enhanced awareness regarding the reduction of material usage that can generate waste, particularly plastic waste, which creates issues in decomposition.

The N Gain analysis is employed to evaluate the effectiveness of implementing the Project Based Hybrid Learning model. The N-Gain test can enhance the validity of the results regarding the effectiveness of the treatment in comparing the control group and the experimental group. The mean results of the N-Gain test for the experimental group and the control group can be seen in Table 12.

The experimental group, which was treated with the Project-Based Hybrid Learning model, showed a mean N-Gain score of 0.33. Therefore, the experimental group demonstrated a significant improvement in the moderate category, whereas the control group, which received treatment through the discussion and question and answer method, showed a N Gain of 0.24, indicating a small increase in the low category. Based on the statistics mentioned earlier, it can be inferred that the experimental group demonstrated significant increase in comparison to the control group. The findings of this analysis demonstrate the effectiveness of using the Project Based Hybrid Learning model in contrast to the discussion and question and answer method in enhancing students' critical environmental awareness. By comparing the N Gain of the control group, which is 0.24 and goes into the low category, with the experimental group, which has a N Gain of 0.33 and goes into the moderate category, it can be concluded that this learning model is helpful in enhancing students' critical environmental awareness.

The project-based learning model requires students to engage in critical thinking, actively participate in problem-solving activities, practice skills in making decisions, conduct research, deliver presentations, and write research papers, so enhancing students' problem awareness. Studying the learning model to the topic of "Utilization of natural resources with the principles of sustainable development" and in the sub-topic "Efforts to Overcome Environmental Problems". The students in the experimental group engage in collaborative activities to create a variety of products using plastic waste. They transform the waste into items such as clothing, bags, wall hangings, and accessories, which they then share among themselves. Students recognize that these plastic waste

products are non-biodegradable waste. This corresponds to other studies indicating that student engagement in activities that directly include or interact with the environment might cultivate students' environmental awareness [78]. Implementing environmental activities in schools can enhance students' environmental literacy [79, 80]. According to a study conducted in China, the implementation of plastic waste management practices contributes to the stability of environmental sustainability [81]. Research performed in Thailand has shown that the adoption of plastic waste management is crucial for creating a clean environment and emphasizes the importance of cooperation from various stakeholders [82].

Implementing the project-based learning model enhances students' abilities as it focuses on engaging students in problem-solving tasks [83]. In the project-based learning model, students actively engage in the learning process rather than passively listen. Engaging students in active learning activities, such as creating or generating ideas through practical tasks or producing concrete products, can enhance their creative abilities and promote a deeper understanding of the material [84, 85]. The projects in this learning model are derived from a collection of student ideas, serving as an alternative approach to address a real issue and allowing students to involve themselves directly in the learning process [86]. According to the study [87], the utilization of the project-based learning model is indicated that Students will experience a variety of things, such as: (1) increasing their skill set [88]; (2) giving them learning opportunities [89]; (3) involving them in the process of learning [90]; (4) boosting motivation [91]; (5) creating an enjoyable learning environment [92]; (6) enhancing their ability to solve problems [93]; (7) encouraging more student participation [94]; (8) fostering more teamwork [95]; and (9) offering support as they learn and practice communication skills [96]. This practice aims to enhance critical attitudes towards daily actions that have the potential to cause damage to the environment, hence promoting environmental awareness. Consistently engaging in this activity is certain to raise the level of environmental awareness.

4. CONCLUSION

The findings of this research demonstrate that implementing the Project-Based Hybrid Learning model has a significant effect on high school students' critical environmental awareness. This is evident from the results of the independent sample T test, which obtained a score of 0.000 or <0.05. Furthermore, the Project-Based Hybrid Learning model has proven to be highly efficient in enhancing students' critical environmental awareness, as indicated by an average N Gain of 0.33. Therefore, teachers can employ this model to adjust learning experiences to the particular characteristics of the topic being studied. The implications of this Project-Based Hybrid Learning model can be applied in other schools, especially schools that are based on the environment, with different variables. However, it must still be based on the existing syntax, paying attention to the dominance of students' kinesthetic learning styles and choosing materials that are concrete and contextual.

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