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Improving Students' Scientific Literacy by The Implementation of PBL Model Integrated with Climate Action

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Abstract

This research aims to analyze the implementation, improvement, and response of students to the implementation of the integrated PBL model of climate action to increase students' scientific literacy at MA Matholi'ul Anwar. This type of research uses quantitative research with a true experiment control group pretest and posttest design. The subjects of this research were from X.1 is class control, X.2 is class experiment 1, and X.9 is class experiment 2. The research data was processed through calculations of learning implementation analysis, prerequisite tests, Wilcoxon test, N-gain analysis, Kruskal-Wallis test, effect size analysis, and student response questionnaire sheets. Based on the research results, it was concluded that (1) the implementation of the integrated PBL model for climate action to increase students' scientific literacy was carried out in the very good category, (2) there were significant differences in students' scientific literacy abilities before and after the implementation of the PBL mode. In class experiment 1 experienced a higher increase as shown by the results of the n-gain analysis with a score of 0.87, a score of 0.79 in experiment class 2, and a score of 0.76 in the control class, thus showing the implementation of the integrated PBL model of climate action effective to implement, (3) students' responses after implementing the integrated PBL climate action model obtained results in the very good category. The research implies that students show an attitude of caring about the environment, namely carrying out reforestation, 3R, and saving energy.

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INTRODUCTION

Humans will always encounter natural symptoms, whether they realize it or not. Most people, when doing their activities, don't pay attention to the natural phenomena that occur around them. The phenomena that occur in nature are closely related to physics. According to Erlinawati (2019), Physics is a science that studies the occurrence of natural phenomena related to the components of a material and the interactions that occur. Scope physics Not only limited to formulas and calculations, physics learns about phenomena nature that occur around Us. Phenomenon nature becomes challenges at times This is a climate change.

Climate change occurs due to human activities which can influence incident change weather and climate extremes around the world. Based on the results report synthesis *Intergovernmental Panel on Climate Change* in 2023, changes in climate cause loss and damage large so that it cannot be restored in terrestrial, freshwater, cryosphere, coastal, and open ocean ecosystems. Impacts on some ecosystems are nearly irreversible, such as the effects of hydrological changes due to retreating glaciers, or changes to some mountain and Arctic ecosystems caused by melting ice sheets (IPCC, 2024). According to Mulyatno (2021), the

trigger happen change climate is the activity man from burning forests, the use of materials that burn excessive oil, and vehicle fumes that can trigger happen effect House glass. Consequently, the change in the climate is becoming a global issue, and then needs to be considered with the association change climate in learning physics (Hartati, 2020). Learning physics can push participants to develop knowledge his knowledge in problem problem-oriented climate. Through learning related physics to the environment or nature, participants will be more interested in solving the problems. Participants are educated Not only to understand the problem with the concept that will studied in learning, but also to necessary their skills that can be developed, earn experience related to learning with method scientific To solve problems, and develop pattern higher thinking (Aini, 2022).

In the 21st century, humans will face an era of human influence on the environment and systems significant on Earth. Knowledge knowledge nature and skill literacy science become important For provisions humans in the future (OECD, 2023). The Organization for Economic Cooperation and Development (OECD) reported that PISA (Program for International Student Assessment) scores on rankings literacy science experience increase of 6 positions for Indonesia in 2022. In 2018, the position ranking literacy in Indonesian science is in 73rd position out of 81 countries. Enhancing literacy science in Indonesia ranks 67th out of 81 countries in 2022. Literacy scores in Indonesian science fell 13 points, equivalent to average points for international experience a decrease of 12 points (Kemendikbudristek, 2023). Literacy science needs students to know, appreciate, and be able to do something if a science-related problem occurs that requires using scientific knowledge and technological knowledge (OECD, 2023).

Scientific literacy is directed at scientific phenomena, as well as incidents influencing nature Participants are educated in using their scientific knowledge to create new ideas, concepts, and conclusions. In learning physics, scientific literacy also supports participants educated and capable create implementation tests in a way independent based on research that has been done, so participants are educated and capable evaluate results investigation scientific that have been carried out (Fuadi, 2020). In the eyes lesson physics, ability participants' scientific literacy can increase the ability critical think critically, think analytically, and solve related problems with phenomena nature in life every day (Millenia, 2020). From the researcher's observations before conducting the research, information was obtained that the research was expected to be able to improve scientific literacy skills in physics material. Natural events around us in the form of climate change are currently also a major topic of conversation.

Climate change is a big challenge that requires contributions from all aspects, especially the educational aspect (UN, 2024). Give SDGs learning in the learning process physics in line with objective development sustainability (SDGs). Ignorance participants educated about draft knowledge change prevailing climate in life can give rise to threat real for continuity of life humans in the future (Mardiyanti, 2020). Necessity declaration education action climate, participants will involved active as activist environment, sensitive will change the climate, as well push participants educate become agent action climate. SDGs Points 13^{th} can embedded in learning physics material global warming (Mardiyanti, 2020). Learning physics in a sustainable education system makes students more creative and active, able to increase students' awareness of environmental problems, and can solve global problems and combat climate change (Jauhariyah et al., 2019).

Physics learning integrated with action learning climate on the SDGs can applied to class X material global warming. On implementation learning, participants educate expected own Skills To analyze symptoms of Global warming and its impacts on life and the environment around, as well as capable connecting problem to the impact given, so bring up

attitude For contribute in overcoming problem global warming with convey ideas/ thoughts (Permendikbud, 2018). The use of an integrated PBL model with related material with Global warming is spot on to be applied to physics subjects. The application of the PBL model can encourage students to investigate climate change issues more closely so that students have the desire to take environmental actions that can minimize the causes of climate change (Yao, 2022). According to Wróblewska & Okraszewska (2020), Problem-Based Learning can increase students' awareness of the environment. The PBL model also involves students in carrying out project activities related to the environment. Students will also play a role in solving environmental problems. The use of the PBL model in the physics learning process as the implementation of a series of learning activities carried out by students emphasizes the process of scientific problem-solving (Akuma, 2019).

Based on the background that has been explained, the researchers conducted research entitled "**Improving Students' Scientific Literacy By Implementation PBL Model Intergrated With Climate Action**". This research was conducted to analyze the implementation of the climate-action integrated PBL model to increase students' scientific literacy, increase students' scientific literacy skills by implementing the climate action integrated PBL model, and students' responses to learning using the climate action integrated PBL model to increase scientific literacy abilities. The limitations of the problem in the implementation of the research are that it was carried out in class X MA Matholi'ul Anwar in 3 classes, implementing the integrated PBL model for Climate Action, in physics learning of climate change material, and the indicators studied were scientific literacy skills. This research is important to carry out to improve students' scientific literacy skills by implementing the PBL model which is integrated with climate action (Krisdiana, 2023). Students will be more motivated and more interested in active learning in the learning process and will be able to investigate problems that challenge curiosity and provide solution ideas regarding climate change problems. The implementation of the integrated PBL model for climate action is also expected to inspire teachers to implement the learning process on climate change material. This research is also used to develop researchers' abilities to apply the PBL model integrated with climate action to increase students' scientific literacy.

METHODS

The type of research carried out is descriptive quantitative. Research methods used in the research This is true experimental (Prahani et al., 2020). The research design carried out is randomized subjects control-group pretest-posttest design (Jatmiko et al., 2018). In research there is class experiment 1 with an integrated PBL model action climate, class experiment 2 with the PBL model, and class control with conventional models, both will be held pretest and posttest. The study used 3 class samples random at MA Matholi'ul Anwar with determination class random use spin application obtained results that class X.1 represents class control, X.2 represents class experiment 1, and class X.9 represents class experiment 2.

Analysis of observational data is used to determine the implementation of the learning process carried out in the classroom. The following are the categories of criteria for assessing learning implementation in Table 1.

Table 1. Criteria Evaluation Observation

Score	Criteria
0.00 – 1.49	Not enough
1.50 – 2.49	Enough
2.50 – 3.49	Good

3.50 – 4.00	Very good

(Hidayatullah & Dwikoranto, 2019)

Learning accomplished with very good criteria if get a score of 3.50 – 4.00, and criteria Good if get a score of 2.50 – 3.49.

Pretest and post-test scores participant education. Pretest and posttest scores were analyzed using the difference test, ANOVA test, and N-Gain analysis. Before carrying out the analysis, carry out prerequisite tests with normality and homogeneity tests. The difference test was analyzed using the paired parametric t-test if the pretest and posttest were normally distributed. If the pretest and posttest are not normally distributed then use the non-parametric Wilcoxon Signed Rank Test. The Analysis of Variance (ANOVA) test was carried out to test the average differences between three or more groups of data using the SPSS statistic 26 application. If one of the assumptions in carrying out the variance analysis is not met, a non-parametric test is carried out in the form of the Kruskal Wallis Test. To find out and analyze the increase in students' scientific literacy skills after implementing the integrated PBL model, climate action was calculated using N-Gain analysis. Learning This is effective if N-gain is categorized currently. Existing N- gain value processed can categorized according to Table 2.

Table 2 Criteria N-gain Score Interpretation

Score	Category
(g) ≥ 0.70	High
0.3 ≤ (g) < 0.70	Currently
(g) < 0.30	Low

(Wardani & Jatmiko, 2021)

Increasing scientific literacy skills is analyzed using N-gain, if it is in the medium category with a score of $0.3 \leq (g) < 0.70$ then learning is effective. After N-Gain analysis, is performed analysis Effect Size is used to measure the strength of the relationship between two variables in a sample-based population in the experimental class. The existing effect size value processed can categorized according to Table 3.

Table 3. Category intervals Effect Size

Score	Category
0.00 – 0.20	Very low
0.21 – 0.50	Low
0.51 – 1.00	Currently
>1.00	High

(Prahani et al., 2020)

The strength of the relationship between two variables in a sample-based population in the experimental class at a score interval of more than 1.00 can be categorized as high. To analyze student respondent data, scoring was carried out. The student questionnaire data scores are based on a Likert Scale.

Table 4. Guidelines score end questionnaire participant educate

Total Final Score (%)	Category
0 – 20	Very less
21– 40	Not enough
41 – 60	Enough
61 – 80	Good
81 – 100	Very good

(Amalia & Hariyono, 2022)

Student questionnaire respondents scored with very good criteria if they got a score of 81-100, and good criteria if they got a score of 61-80. In addition, the response questionnaire will also be explained in detail using descriptive sentences.

RESULTS AND DISCUSSION

Implement Ability

Teacher activities during learning were observed and assessed by 3 observers, namely 2 physics teachers MA Matholi'ul Anwar, and 1 State University of Surabaya Physics Education undergraduate student. The observer observes and assesses teacher activities to know the suitability of teacher activities with stages of the PBL model. As for the results of data evaluation implementation Teacher activities are presented in Figure 1.

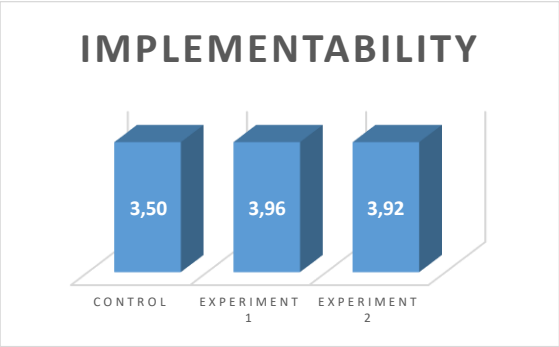

Figure 1. Results Data of Implementation

In the first phase of the PBL model, namely problem orientation, there are activities inviting students to observe the phenomenon by asking questions. In the second phase, namely organizing students by describing the problem by seeking information from all sources. In the third phase, namely guiding student investigations by giving students trigger questions related to solutions to climate change, then students carry out experiments. In the fourth phase, namely developing and presenting results by encouraging students to analyze the data obtained correctly, the teacher encourages students to create their version of green space ideas as a solution to the problem of climate change, this phase takes a long time. In the fifth phase, namely analyzing and evaluating the problem-solving process by reviewing learning materials and providing opportunities for question and answer. Can stated that learning can be accomplished with effectiveness. Activity action climate in research held phase 3 are participant educate carry out experiment room green for get knowledge in solution problem from problem change climate.

Figure 2. Implementation of Phase 3, guiding investigation participants to educate

After that, the teacher encouraged participants to educate for create space ideas green version self Alone as solutions to problem change climate, the teacher encourages participant educate For do review the literature related to designing rooms green made as well and strengthened the results of the analyzed data, the teacher invited participants educate to prepare the results of experiments that had been done, and the teacher points representative group for present results, and the teacher provides chance ask to answer. Activity action climate with help participants educate for prepare report experiment and present ideas as solutions for overcoming problem change climate from design room green version self Alone. The results of the student's work are presented in Figure 4.

Increasing Scientific Literacy Ability

As for upgraded ability, every scientific literacy competence can be known with the use of N-gain calculation. Following is an interpretation of enhancement participants ' scientific literacy education by 3 competencies based on PISA 2022.

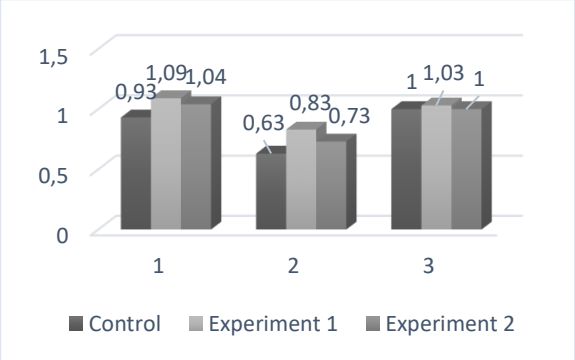

Figure 3. N- *gain* value for each competence in three class

Information:
1 = Competence explains the phenomenon in a way scientific
2 = Competence organize and evaluating designs - designs for investigation of scientific as well as interpretation data and evidence critically
3 = Competence in research, evaluation, and use of information scientific for making decisions and actions

Figure 3. shows the enhanced ability of participants' scientific literacy education at three class studies for 3 competencies of scientific literacy. Entire competence scientific literacy experience enhancement is high at three classes, but on competency second class control experience is enhancement. Enhancement highest second namely on competence in research, evaluation, and use of information for taking decisions and actions. In contrast, enhancement is the Lowest namely on competence to organize and evaluate designs - designs for investigation scientific as well as interpretation of data and evidence scientific in a way critical.

Due to the data not being normally distributed, the Kruskal-Wallis Test was used. The Kruskal-Wallis Test is a non-parametric statistical test that can be used to test whether there is a significant difference between 2 or more groups in the independent variable and its dependent variable. The Kruskal-Wallis Test in this study was conducted using the SPSS application.

Table 5 Kruskal-Wallis Test Results

Ranks				
	Class	**N**	***Mean Rank***	***Asymp. Sig.***
Posttest	Control	27	22,67	0,00
	Experiment 1	28	64,38	

Experiment 2	28	38,27
Total	83	

Table 1 shows the results of the Kruskal-Wallis test obtained by an Asymp. Sig. Value of 0.00, which is less than 0.05. The data also shows that H1 is accepted, namely, there is a significant difference in improving students' scientific literacy skills. The significant difference in improving students' scientific literacy skills in classes that implement climate action integrated PBL shows better results than in classes with the application of the PBL model alone. This is also evidenced by the N-gain analysis in the form of the results of the pretest and posttest improvements in experimental class 1 where the climate action integrated PBL model was applied, experiencing the highest increase compared to experimental class 2 where the PBL model was applied alone and in the control class where only the conventional model was applied, so it can be stated that students' scientific literacy with the application of the climate action integrated PBL model was able to experience better improvements.

Student Response

Analysis response participant education done for analyze response and response participant educate to activity learning that has been done. Questionnaire response participant students used in the study This consists of the 20 must statements filled in a way completed by participants learned in class control, class experiment 1, and class experiment 2. Score statements answer participants ' statements that have been stated in the questionnaire analyzed using the Likert scale per item. There is a difference in the results of the questionnaire responses in the control class and the experimental class. The experimental class produced a better response. Following are the results of questionnaire responses from participants in Table 5.

Table 6. Questionnaire results response participant educate

No	Statement	Highest Score (%)
1.	The PBL model in physics learning can attract interest in learning	53.57
2.	The application of the PBL model makes learning physics fun	71.43
3.	The learning material is easy to understand because the PBL model is applied	57.14
4.	The PBL model can encourage me to find new ideas	53.57
5.	The application of the PBL model gave me motivation to be enthusiastic about studying physics	60.71
6.	Learning physics using the PBL model can make me more active in learning	46.43
7.	The application of the PBL model in physics learning can foster interest in reading	57.14
8.	Learning physics using the PBL model can produce an understanding of various natural phenomena in the surrounding environment.	57.14
9.	The application of the PBL model in physics learning can produce scientific knowledge	50.00
10.	The application of the PBL model in physics learning can foster decision-making attitudes and actions using various sources of information.	46.43
11.	The application of the PBL model in climate change material can foster an attitude of caring for the environment	100.00

No	Statement	Highest Score (%)
12.	The application of the PBL model in climate change material can encourage me to look for problems causing climate change.	57.14
13.	The application of the PBL model in climate change material can encourage me to look for solutions to climate change	100.00
14.	The application of the PBL model in climate change material can increase reading interest to seek broader information related to the phenomenon of climate change.	75.00
15.	The application of the PBL model in climate change material can foster curiosity to carry out scientific investigations	39.29
16.	Studying physics related to natural phenomena can improve investigative abilities	42.86
17.	Learning physics related to nature can attract interest in learning	78.57
18.	With climate action, I am more concerned about the phenomenon of natural destruction in the surrounding environment	96.43
19.	Can find solution ideas for climate change problems with scientific identification skills	67.86
20.	Studying physics related to natural phenomena can improve literacy skills	75.00

Discussion

Implement Ability

Implementability of PBL model learning is carried out with observation towards teachers (researchers). Observation was carried out by two teachers MA Matholi'ul Anwar and one State University of Surabaya Physics Education undergraduate student. Observation was done in class control, class experiment 1, and class experiment 2. Value results observation collected become One evaluation Then analyzed and concluded. Observation done adjusted to the phase of the learning model applied in each class. In class, experiment 1 and class experiment 2 applied the PBL model with 26 aspects assessment of the 5 phases of the PBL model. The phases of the PBL model are: 1st phase is orientation problem, 2nd phase is organizing participant education, the 3rd phase, namely guide investigation, 4th phase developing and presenting results, 5th the analysis and evaluation of the solving process problem. Additionally, aspects assessment also consists of introduction and conclusion activity learning.

In research, this 3rd phase of the PBL model guide investigation participant education is phase most important in the study. After knowing the symptoms, causes, and impacts of the problem change climate, the teacher provides question lighters to participants to educate related opinions on overcoming the problem change climate. This matter makes it possible for participants educated for involved more in understanding and completing the problem environment, which stimulates critical thinking, so in the activity Study participants educated show enhanced activeness (Nurhayati, 2023). Participants carry out experiments in room green as modeling to get knowledge with do solution problem from problem change climate. On implementation, participants educate each other and collaborate to finish the experiment, producing an understanding of related problems (Wijayanti, 2023). After that, participants prepare a report experiment and convey ideas as solutions for overcoming the problem change climate from design room green version self Alone. Can stated that learning can be accomplished with effectiveness. The obstacle that arose in carrying out the research was that it took a long time to experiment, so the researcher used certain tactics to overcome this.

Increasing Scientific Literacy Ability

Enhancement ability scientific literacy is known with the use of instrument study form question pretest and posttest. Pretest and posttest questions consist of 10 question essay that includes 5 indicators that participants can analyze the difference change climate and global warming, participants can analyze symptoms, causes, impacts, and solutions to change the climate as well as global warming in life daily, participants educate can serve results analysis symptoms, causes, impacts, and solutions on change climate in life daily with That's right, participant educate can create scientific ideas as a solution from happen change climate in life daily life, and participants educate can evaluate action influential every day to change the climate. 5 indicators are explained from three competencies scientific literacy, that is competence in explaining the phenomenon in a way scientific, compiling and evaluating designs for investigation scientific as well as interpreting data and evidence in a way critical, as well as research, evaluating, and using information scientific for taking decisions and actions.

Figure 3 shows the N-gain *value* for each scientific literacy competency in three classes. The competency that experienced the highest increase was the competency to explain phenomena scientifically as seen from the value of increasing students' scientific literacy abilities which was calculated from the difference in *pretest* and *posttest scores* in each class. Competence explains the phenomenon in a way scientific experienced competence enhancement highest namely in class experiment 1 with a score of 1,09, because class experiment 3 implemented an integrated PBL model action climate. From the process of learning activities and results *post-test* answers in all indicators, can stated that implementation of the PBL model is capable push participants educate for achieve 3 competencies literacy science, participants open looking for information about problem change climate, and global warming from any media, as well capable involve participant educate in activity experiment modeling enhancement temperature at room green For get an explanation and solution problem from change climate, so participant educate come up with solution ideas minimize reason change climate with action care environment or action climate (Yao, 2022). Participant students are also capable evaluate actions taken causing the world to experience an emergency climate. Evaluation action that, grows attitude solve problem environment with integration action climate in each stages syntax learning and showing action care environment.

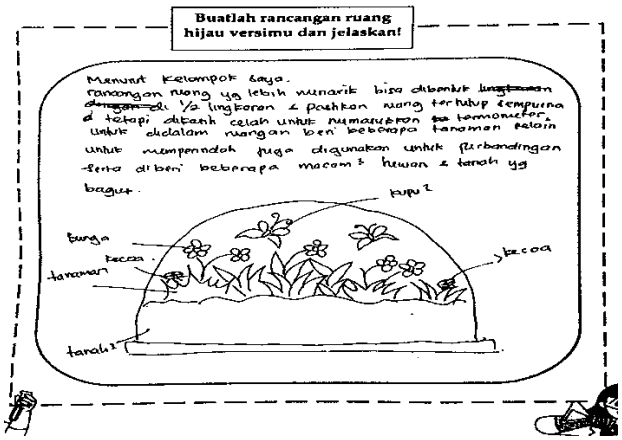

Figure 4. Green Room Design Version Learners

Figure 4 shows that students can create a student version of a green space design that can be used as a solution to minimizing climate change problems. Making design room green can made as an idea or idea in handling action climate in the environment schools that can applied in learning Physics. Green space This works as a producer of oxygen, absorbent carbon

dioxide, and water storage in the soil (Qathrunnada, 2019). Participant Educate also shows an attitude care environment with a form of "**Rose Cares**" activities aimed At the care environment. The "Rose Cares " activity is not only a clean room class with sweep, participants also plant trees, manage waste, no use material use, as well save use energy. From attitude, then can stated that participants have applied action climate in life daily.

Enhancement ability literacy science participant learned in class control of 0.76, in class experiment One 0.87, and class experiment two 0.79. Based on the results enhancement ability literacy science participants the show that class experiment 1 obtained enhancement ability literacy science participants highest with the implementation of an integrated PBL model action climate. Increase value highest second is class experiment 2, meanwhile, class control is class enhancement Lowest. The data also states that learning in three classes was accomplished in a way effective, and improved ability literacy science participant experience enhancement categorized.

Student Response

Response participant education obtained from results sheet questionnaire response participant equipped students after implementation activity learning. Response participant educate This shows response participant is educated about the activity learned that has been done. In the statement regarding the application of PBL to climate action, namely, the application of the PBL model in climate change material can foster an attitude of caring for the environment. This shows that 100% of students strongly agree with the statement. According to research by Hartati (2020), learning about climate change can give rise to new habits to participate in protecting the environment. In the statement that with climate action I am more concerned about the phenomenon of natural destruction in the surrounding environment, 96.43 students stated that they strongly agreed with this statement. This is in line with research by Hartati (2020), that sustainable learning that is climate literate, can create an attitude of awareness of environmental damage by carrying out environmental care activities. From the response questionnaire, it can be seen that the application of the integrated PBL model for climate action to improve students' scientific literacy skills at MA Matholi'ul Anwar received a positive response.

CONCLUSION

The implementation of the integrated PBL model for climate action was successfully implemented in the very good category. The average implementation score obtained from 3 observers in the control class was 3.50, with a very good category, in experimental class 1 the score was 3.96, in the very good category, in experimental class 2 the score was 3.92, with a very good category. Increasing students' scientific literacy skills in the high category in experimental class 1 with an N- *gain value* of 0.87 with the application of the integrated PBL model of climate action, in the high category in experimental class 2 with an N- *gain value* of 0.79 with the application of the PBL model, and in the high category in the control class with an N- *gain value* of 0.76 with the application of the conventional model. The application of the integrated PBL model for climate action to increase scientific literacy has received a very good response from students and can foster an attitude of caring for the environment so that it can be used as an innovation for physics learning. Implications for the implementation of the integrated PBL model for climate action are that the green space experiment can be used as an example of modeling temperature changes that occur due to human activities that can cause climate change problems, and students demonstrate an attitude of caring for the environment, namely carrying out reforestation activities, 3R, and saving energy.

SUGGESTION

Future research can use research media related to climate action to support research implementation activities to produce comparisons of the results of increasing scientific literacy skills using different climate action media such as miniature solar panels, miniature air turbine models, miniature natural disaster detectors, and is expected to discuss data graph analysis studies, to provide information to students on how to analyze graphs data correctly.

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