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Research Artikel

ENHANCING CRITICAL THINKING ON CLIMATE CHANGE: TPACK IMPLEMENTATION IN PBL WITH DIGITAL POSTERS

Shelly Efwinda[1*], Irma Puspita[2], Puardmi Damayanti[3], Abdul Hakim[4], Muliati Syam[5]
[1, 2,3,4,5] Physics Education Study Program, Mulawarman University, Indonesia
shelly.efwinda@fkip.unmul.ac.id[1]*

Abstract

Critical thinking skills are vital in the 21st Century to identify solutions to real-world problems like climate change. This research aims to test the effect of integrating the PBL (Problem-based Learning) Model with Digital Posters within the TPACK (Technological, Pedagogical, and Content Knowledge) framework on the critical thinking skills of junior high school students in Samarinda on climate change. The research approach used is quantitative with a quasi-experimental method involving two classes, an experimental and a control class. The treatment given to the experimental class was the PBL model with the help of digital posters, and the control class used the traditional lecture method. Data on students' critical thinking skills was collected using a test technique in the form of 10 essay questions. Data analysis techniques used quantitative descriptive and T-tests. The research results showed significant differences in the critical thinking skills of the experimental and control classes after each class was treated. Based on these findings, it recommends the need for similar adoption by teachers in teaching complex topics such as climate change. These results also show the importance of integrating technology in learning to support the development of student's critical thinking skills, especially in understanding complex topics.

Keywords*: Critical Thinking; Climate Change; Junior high school students; Problem Based Learning (PBL); TPACK.*

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*Corresponding author
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INTRODUCTION

The demands of individuals in 21st-century life are increasingly complex; current and future generations are faced with increasingly complex problems that require various types of skills by the individual to find solutions to existing problems; critical thinking, teamwork, and problem-solving skills must be constructive (Susilawati, 2019). Developing critical thinking skills is and students at every level of education need to have these skills (Aji, 2019). Many educators are trying to cultivate critical thinking skills in their students (Mohamed Nor & Sihes, 2021). As the future generation, it is hoped that students will be prepared to master 21st-century skills (Fadillah et al., 2018). In critical thinking skills, students are expected to be able to generate and organize ideas, analyze facts, defend opinions or arguments, and then conclude and solve existing problems (Abdullah & Suhartini, 2017). Critical thinking skills need to be developed and trained as soon as possible in students so that they are ready to become the next generation with good critical thinking skills, contributing to finding solutions to real-world problems.

Students must demonstrate critical thinking when they produce and assemble ideas, assess data, draw valid conclusions, defend opinions or arguments, and solve existing problems (Abdullah & Suhartini, 2017). Critical thinking skills strongly correlate with scientific literacy (Rahayuni, 2016; Ridzal & Haswan, 2023). However, the PISA (Program For International Student Assessment) shows that Indonesia ranks 75th out of 80 countries in science literacy, with an average of 396 and an average understanding of the cognitive domains C5 and C6 of 0.08% (OECD, 2019). Rosidah & Sunarti (2017) stated that the leading cause of low PISA results is students' lack of training in solving complex problems. According to Andika & Setyarsih (2019), the intended problem is a problem that requires each individual's critical thinking process. TIMSS (Trends in International Mathematics and Science Study) and PISA surveyed the students' critical thinking skills in Indonesia with the results of the ability to be at the low-order thinking stage with a percentage of 45% (Lane & Oswald, 2016). Therefore, it can be stated that the critical thinking skills of junior high school students are still relatively low, especially at the international level.

Malikha (2018) stated that developing students' critical, logical, and creative thinking skills can be done through innovative and student-centered learning models. However, observations at one junior high school in Samarinda show that science learning carried out by teachers still uses the lecture method and uses less interactive learning media in its delivery, as well as learning that is still teacher-centered, resulting in student learning outcomes that are still lacking and do not meet the Minimum Completeness Criteria in the school is 75. This is in line with the statement by Wahyuni & Ananda (2022), which states that teachers at junior high schools still use the lecture method assisted by textbooks and blackboards. Jannah et al. (2016) stated that some teachers in the learning process only provide mathematical representations and concepts read through books to make students with poor mathematics skills struggle to understand physics concepts. This learning method is ultimately only able to make students remember concepts but has not trained students' critical thinking skills to think convergently, logically, and reasoning, which are some of the characteristics of critical thinking (Farisi et al., 2017). Komariah et al. (2018) stated that the learning methods of lectures, discussions, and practice questions often make students bored with learning, resulting in students becoming too lazy to read or pay attention to the teacher. In traditional learning, the teacher only transfers knowledge to students, causing students to take notes, listen, and be passive in building knowledge to make conclusions from what the teacher has conveyed (Barta et al., 2022). When viewed from previous problems,

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teachers still do not use learning models and media that make students play an active role in the learning process. Based on this, improving the learning process to grow and train junior high school students' critical thinking skills is necessary.

Research conducted by Budhi & Suwarni (2019) and Samadun & Dwikoranto (2022) shows that the Problem-Based Learning (PBL) model is efficacious in improving students' critical thinking skills and using a PBL framework that places students in situations where they may practice critical thinking and problem solving and understand the concept of the material to be learned (Anwar & Jurotun, 2019). The PBL model has been proven to be used to improve critical thinking skills in previous studies (Yu & Zin, 2023). Among others, as stated by Aswan et al. (2018), Hussin et al. (2018), and (Asri et al., 2024), and Rusmono (2017), the PBL learning model has stages in applying it, namely, organizing students on a problem and organizing students to learn, investigate, analyze, and evaluate problem-solving. The learning stages in the PBL model are very suitable for improving critical thinking skills.

The PBL model is also considered adequate for sustainable education related to climate change (Rubini et al., 2020; Sukackė et al., 2022). Critical thinking is an asset that needs to be possessed to solve complex issues facing the world today because overcoming this issue requires thinking by organizing ideas, analyzing facts, and providing solutions. One of the topics taught at the junior high school level that requires critical thinking skills is related to climate change. Climate change is one of the consequences of global warming; since the mid-20th Century, global warming has emerged as a real challenge that cannot be avoided (Environmental Protection Agency, 2018). According to Alvita & Wasis (2017), the impact of global warming is very detrimental, requiring all parties to take adaptation and mitigation steps against this problem. Azizah & Rosdiana (2022) stated that critical thinking could help solve various problems around humans, such as environmental problems. Critical thinking skills are an essential competency to increase individuals' understanding of the situations that occur on earth and around them (Özelçi & Çalışkan, 2019). Critical thinking skills are capital for deciding what essential actions to take to combat climate change (Vaughter, 2016). Climate change education at the school level has several challenges, including selecting appropriate strategies, media, and teaching materials (Hakim et al., 2023). Teachers not only need to choose the suitable model, such as using the PBL model to improve students' critical thinking skills on the topic of climate change, but teachers also need to choose the appropriate media and be able to integrate it with the PBL model.

The learning process also needs to be supported by learning media to create an active learning atmosphere and more effective and efficient communication between teachers and students; not only that, it can motivate and encourage students to write, speak, and imagine (Nurfadillah et al., 2021). Yusuf et al. (2022) researched the development of image media in the PBL model, proving that it could improve students' critical thinking. Saharsa et al. (2018) examined the effectiveness of applying the PBL model assisted by video media, and this research has proven to improve students' understanding of physics concepts. Santoso et al. (2020) researched the effect of PBL assisted by teaching aids, and this research has also proven to improve students' critical thinking. PBL integrated with digital teaching materials can facilitate student learning activities to connect real-world problems with concepts and facts and improve students' critical thinking skills (Chairudin & Dewi, 2021; Milama et al., 2023). Previous research shows that the PBL model can be integrated with various learning media, such as images, videos, teaching aids, and digital learning media, and has been proven to contribute to student learning outcomes.

As teachers, we need to be able to choose and use suitable learning models and media that suit the needs and developments of today's times. Technological developments that occur so quickly and influence life in the 21st Century, including in education, for example, using digital technology as a learning medium. Teachers' skills in integrating technological knowledge with content and pedagogical expertise in learning are necessary for the 21st Century (Efwinda & Mannan, 2021). TPACK (Technological, Pedagogical, and Content Knowledge) implementation can improve learning quality by improving teachers' teaching skills (Septiandari et al., 2020) by creating effective student learning (Masrifah et al., 2018). Therefore, to enhance students' critical thinking skills through implementing TPACK, teachers need to choose appropriate learning models and media to be integrated, which can facilitate the development of students' critical thinking skills. This research used digital poster media combined with the PBL model as a new media from previous research. Implementing the PBL model with the help of digital posters is one of the TPACK implementation efforts that was tried to be implemented in this research.

According to Rizawayani et al. (2017), poster learning media is one of the media consisting of straightforward symbol words; posters also have a visual combination of solid designs, with colors and messages intended to capture the attention of students; moreover, it is believed that the use of posters would encourage students to become more engaged in their education. Making designs can also stimulate students' critical thinking skills (Tang et al., 2020). According to the research results by Rahayu & Cintamulya (2019), using poster media in learning can help improve students' thinking. Through poster media, students can see problems in the surrounding environment, making it easier to analyze problems, causes, impacts, and solutions to problems. This is also supported by research by Vong & Kaewurai (2017), which uses posters as learning material for students to analyze, and the results can improve their critical thinking skills. Research by Khastini et al. (2021) also shows the development and use of E-Poster media, which enhances students' critical thinking skills. The use of poster media in learning has many benefits, including increasing student attention and involvement and can develop students' thinking systems, including critical thinking skills.

However, from existing research, no one has specifically applied the integration of the PBL model with digital posters to improve students' critical thinking skills on climate change. The topic of climate change is complex, and some concepts are abstract, so they require the help of digital technology as a medium of visualization. Based on the theories and relevant studies presented, this research aims to test whether the application of the PBL Model assisted by Digital Posters as a TPACK Implementation could further improve students' critical thinking skills compared to conventional learning models with the lecture method.

METHOD

The study design used was a nonequivalent (pretest-posttest) control group design, and the approach taken was quasi-experimental. There were a total of 5 meetings for the study, and each one lasted for 2 hours and 40 minutes. This study was conducted during the 2022-2023 school year at a junior high school in Samarinda. Purposive sampling was employed to choose two groups of students to participate in the research. The consideration in selecting the sample was the teacher's recommendation, which stated that the average ability of students in both classes was the same or homogeneous. The number of students in the experimental and control classes was 35 students each.

The traditional learning model was employed in the control class through teacher-centered learning with the lecture method. Each learning activity begins with an apperception

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and introduction by the teacher, then continues with the delivery of material, practice questions, and conclusion. In contrast, the PBL Model using Digital Posters (as a form of TPACK implementation) was utilized as a treatment in the experimental class. The phases of the PBL model used in this research are as follows: introduction; issue orientation; student research organization; student inquiry guidance; student work development and presentation; problem analysis and evaluation; closing. Digital poster assistance in this study is that the poster media is made by the teacher containing information on the theme of climate change to attract students' attention so that students can connect learning materials with real problems. In addition to the teacher making posters, students also make digital posters that answer the questions on the student worksheet. The digital poster is created using a digital application such as Canva.

Implementing learning in the experimental class using the PBL model assisted by digital posters is carried out in several steps. In step 1, the teacher displays a poster about climate change facts and then provides an orientation about the problems surrounding students' lives. The teacher presents the current climate change problem, which requires alternative solutions; providing an orientation to the problem must attract and arouse students' curiosity and inquiry. Step 2, the teacher organizes students to research or study to develop collaboration skills among students and helps them to investigate climate change issues together. Investigative activities regarding information about climate change require students' willingness and curiosity to obtain information from the investigations carried out. Step 3, the teacher guides the investigation; in this step, students can understand and express the problem because in this step, apart from obtaining a solution to the problem, students will also develop a hypothesis to explain and provide a solution to the problem of climate change. In step 4, the teacher creates and presents the work. In this step, students prepare the work that will be given. The result of the work is in the form of a poster. By presenting their work, students will increase their self-confidence. In step 5, the teacher guides students in analyzing and evaluating solutions to problems from the climate change material they have obtained.

This research gathered data on students' critical thinking abilities using a testing technique. The exam consisted of two parts, a pre-and post-test. The test is developed as an essay based on critical thinking indicators: Focus, reason, inference, situation, clarity, and overview. Before being tested on students, the essay questions were first validated by three material experts through focus group discussions conducted twice. In FGD (Focus Group Discussion) 1, several questions need to be revised to adapt to the indicators of critical thinking skills. After revision, FGD 2 was carried out, and agreement was obtained that the revised questions were suitable for use and testing on students. The total number of questions used is ten essay questions.

The data analysis technique used is descriptive quantitative and T-test. The students' pre and post-test results, which have been processed in numerical form, are then categorized using the category criteria presented in Table 1.

Table 1. Category Criteria for Students' Critical Thinking Skill Level

Score Criteria	Category
$81{,}25 < x \leq 100$	Very Critical
$62{,}50 < x \leq 81{,}25$	Critical
$42{,}75 < x \leq 62{,}50$	Moderately Critical
$25{,}00 < x \leq 42{,}75$	Less Critical

Before carrying out a T-test on post-test data, prerequisite tests are first carried out as normality tests and homogeneity tests. The normality test is carried out to assess the distribution of data in a group of data or variables that are normally distributed or not. The normality test in this study used the SPSS application. For decision-making in the

Kolmogrov-Smirnov normality test, namely, if the significant value (sig) is > 0.05, then the data is normally distributed. Still, if the significant value (sig) < 0.05, the data is not normally distributed. Apart from the normality test, a homogeneity test was also conducted using the SPSS application. The basis for decision-making in a homogeneous test is that if the significant value (sig) is > 0.05, then the data is homogeneous. Still, the data is not homogeneous if the significant value (sig) is < 0.05. If the data is normally distributed and homogeneous, proceed with a parametric test in the T-Test. The purpose of the T-test is to analyze whether there is a statistically significant difference between the critical thinking abilities of students in the experimental group and those in the control group.

RESULT AND DISCUSSION

This research was conducted at a junior high school in Samarinda for five meetings, where each meeting was held for 2x40 minutes.

Pretest

Class VII G was the control group, while VII H was the experimental group. Before implementing the PBL learning model, students in both groups took an initial exam to measure their critical thinking skills—ten essay questions comprised the whole exam. The pretest scores of the pupils in the control group show that there are no students whose scores reach the completion of minimum criteria, which is 75; many students still score below the completion of minimum criteria with a range of control class pretest scores ranging from 10-36. Data analysis of the experimental class students' pretest shows that no students' scores reached the completion of minimum criteria, with the control class pretest scores ranging from 10-40.

Post-test

Class VII G received traditional instruction, whereas Class VII H used the PBL learning model supported by poster media. Researchers carried out this step to develop students' critical thinking skills. The post-test was administered during the last meeting. The test items were the same as those given during the pretest, which comprised ten essay questions. The post-test results of the control class students show that students in the control class get scores from 72-84 while those in the experimental class get 76-90. Students ' scores generally increased after learning activities in both the control and experimental classes, although with different improvement ranges. The maximum score obtained by students in the control class was 84, while in the experimental class, it was 90.

Assessing students' critical thinking skills aims to provide an overview of the level of students' critical thinking before and after treatment. The control and experimental class critical thinking category assessment is presented in Table 2.

Table 2. Students' Critical Thinking Category in Control and Experimental Class

Category	Control		Experiment		Control		Experiment	
	Pre		Post		Pre		Post	
	Total	Percentage	Total	Percentage	Total	Percentage	Total	Percentage
Very Critical	0	0%	0	0%	10	29%	21	60%
Critical	0	0%	0	0%	25	71%	14	40%
Moderately Critical	0	0%	0	0%	0	0%	0	0%
Less Critical	0	100%	0	100%	0	0%	0	0%
Total	100%		100%		100%		100%	

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Table 2 shows no critical thinkers existed in the control and experimental groups before receiving treatment; all students performed in the less critical category. There was still a need to improve students' critical thinking skills. Furthermore, the table also shows that the critical thinking skills of the control class students improved after being given the treatment. There were 25 students in the critical category and 10 in the very critical category.

The post-test result in the experimental class shows 14 students in the critical category and 21 in the very critical category. Based on these numbers, it seems that most students in the experimental group rise into the "very critical" category. It follows that the PBL learning approach, with the help of digital posters, is essential for developing students' critical thinking skills.

a. Hypothesis Testing Analysis

It is necessary to test the hypothesis to analyze the effect of students' critical thinking skills in experimental and control classes. Students in the experimental class, who are utilizing the PBL model with posters, will be compared to students in the control class, who use the more traditional methods of instruction. Students in the experimental class, who were taught using the PBL model supplemented with posters, showed much higher levels of critical thinking than students in the control class, who had been taught using the more traditional methods.

To test the hypothesis using the t-test, before the t-test is carried out, it is necessary to test the prerequisite analysis first, namely the normality test. After obtaining the results that the initial test data and the final test are normally distributed, the t-test can be done. The SPSS output shows a significant difference in the mean scores on the critical thinking subtests between the control and experimental groups, with a p-value of 0.000 indicating statistical significance. Students in the experimental group, who used the PBL approach aided by poster media, significantly outperformed those in the control group, who had been taught using the more traditional methods.

The t-test was then used for statistical analysis to verify the null hypothesis, and the findings were statistically significant. Therefore, the PBL model supplemented with posters significantly impacts critical thinking abilities. Research by Thadsaniyom & Sangpradit (2019) demonstrates that students' critical thinking scores improve after exposure to the PBL model. This indicates that the PBL approach may help students develop higher levels of critical thinking. Hursen (2021) likewise demonstrated that the PBL group's learning outcomes and critical thinking abilities were much higher than those of the traditional model group. The findings of a study by (Widiawati et al., 2018) supported the idea that PBL has the potential to foster the kind of critical thinking that is essential for success in the modern classroom. The findings corroborate those of Mardhani et al. (2022) in demonstrating a statistically significant improvement in students' critical thinking abilities between pre- and post-testing periods.

There are discrepancies in the outcomes of student replies on pre- and post-test questions between the control class utilizing traditional learning, i.e., the lecture technique, and the experimental class using the PBL model supplemented by poster media. This can be seen from the pattern of answers of control and experimental class students when working on pretest and post-test questions. Figures 1 and 2 show that during the pretest, many control class and experimental class students tended to give answers without giving reasons for the problems given. For example, in question 1, Indonesia is on the equator and has a tropical climate. The climate in Indonesia has two seasons, namely the dry and rainy seasons. According to BMKG, weather changes in Indonesia often change irregularly. We also often experience changes in the weather lately; what starts as scorching heat in the morning can become heavy rain in the afternoon. Why does this happen?.

The responses of the control group and the experimental group to the pretest are as follows:

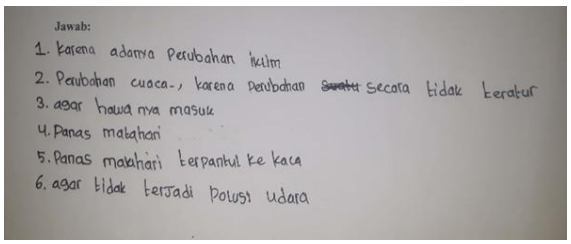

Figure 1. Control class students' pretest answers

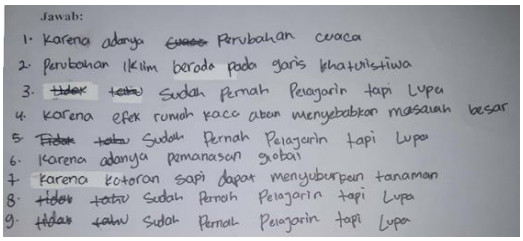

Figure 2. Experimental class students' pretest answers

According to Figures 3 and 4, student performance on the post-test varies across the control and experimental groups; students answer correctly but do not give reasons for the problems given, in contrast to the experimental class, who answer correctly and try to give reasons for the problems given. The followings are the post-test answers of the control class and experimental class:

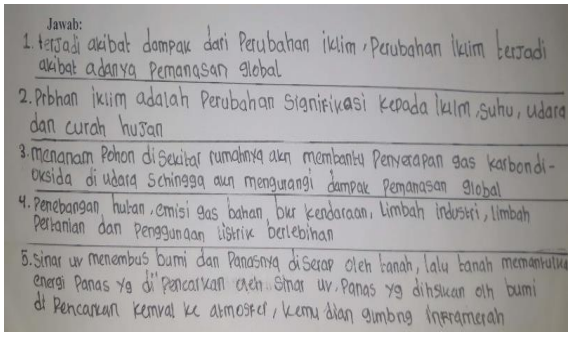

Figure 3. Post-test answers of control class students

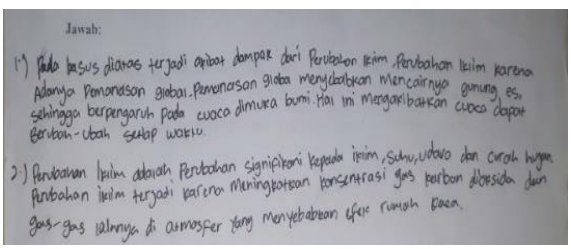

Figure 4. Post-test answers of experimental class students

In the first stage of PBL, namely problem orientation, students can think to determine the solution to the problems the teacher gives. This can train students' critical thinking skills, namely focus where students focus on the issues presented by the teacher. In this stage, the teacher displays a poster about climate change facts and then provides an orientation about climate change problems surrounding students' lives. The teacher presents the current climate change problem, which requires alternative solutions; providing an orientation to the problem must attract and arouse students' curiosity and inquiry.

In the second stage, organizing students to research where the teacher ensures that students understand the tasks given. The third stage, namely developing student investigations, can train students' critical thinking skills, namely focus and reason, where students are asked to focus on the problem and be able to express the reasons for the problem. The fourth step, which entails creating and presenting the finished product, may help pupils hone their critical thinking abilities, namely the process of drawing conclusions and situations. When students conduct discussions to produce problem-solving solutions, students can already conclude and read the situation of the problem.

The fifth step is to assess how well the issue was solved. This may help kids develop critical thinking skills, namely clarity and review. Students have good clarifying and reviewing skills when they can explain the problem given and review the appropriate solutions to solve the problem. For the experimental class at the second meeting, students also experimented on the impact of global warming; where after the teacher gave a problem, namely how global warming affects the ecosystem, students observed the effect by conducting a simple experiment. The documentation activities are presented in Figure 5.

Figure 5. Practical Activities

In the learning process, students are also tasked with making digital posters related to the worksheet tasks at each meeting. Figures 6, 7, and 8 are examples of the poster work created by students:

Figure 6. Poster artwork from the first meeting

Figure 7. Poster artwork from the second meeting

Figure 8. Poster artwork from the third meeting

Poster media is a medium for conveying messages or information through images and writing. In making this poster, the media used by students is the Canva application, which can be used for free by students. Through this poster learning media, students actively investigate problems to get solutions to problems, in line with the opinion of Elisandra & Arief (2017), which suggests that poster media can increase students' interest in learning and act as a link between the content of learning materials and problems that exist in the real world. Additionally, research conducted by Intaha et al. (2020) also states that poster media is not only an intermediary medium for students and teachers, but students can practice the meaning of posters. In the results of this study, experimental class students who made posters tended to be able to understand the problems given by the teacher and were more enthusiastic about participating in learning.

The results of this study align with the opinion of (Koroh & Ly, 2020), which states that the stages in the PBL learning model can motivate students' active involvement in solving problems not only it can facilitate the improvement of critical thinking skills very well. Additionally, research conducted by Efwinda et al. (2022)

showed an increase in pretest and post-test scores after participating in training activities on making digital posters with a global warming theme. (Widiawati et al. (2018) also have a similar opinion, stating that the PBL model can facilitate students in getting and finding strategies, solutions, and concluding a given problem so that it is aligned with the process of critical thinking skills; this can also motivate students to continue practicing critical thinking. Fidan & Tuncel (2019) argue that this PBL model is not to help students get as much information as possible but to help develop students' ability to improve critical thinking skills, make students learn various roles with involvement in solving problems, and make students active and independent.

This research shows that implementing TPACK through integrating the PBL model assisted by digital posters improves students' critical thinking skills related to climate change topics. The implementation of TPACK in teaching needs to continue; further research can be carried out by developing specific technology to be integrated with the PBL model, for example, as done by Nafidiah et al. (2023), who developed Digital Game-Based Learning Based PBL-STEM for climate change material. Even though students already know that climate change is occurring, many have misconceptions about how this climate change can happen (Thacker & Sinatra, 2019). The concepts in Climate Change Material require visualization, which can be assisted with the help of technology (Queiroz et al., 2023) (Brannon et al., 2022).

CONCLUSION

Research on the impact of the PBL model with poster media on students' critical thinking skills shows a statistically significant difference in students' critical thinking abilities in the experimental class using the PBL model with poster media. These results show the benefits of integrating the PBL model and poster media in improving students' critical thinking skills. Further research can be carried out by integrating specific learning approaches, models, or methods with technology to support 21st-century learning, especially on complex and abstract topics where technology can help visualize the topic.

The limitations of this research include that it was only carried out on a small sample, only at one school in Samarinda. It is hoped that future research can be carried out on a larger sample to make the results more representative.

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