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Boys and Girls in Developing Scientific Literacy Through Problem-based Learning Supported by ClimateClass

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Abstract

This study examines the effectiveness of the Problem Based Learning (PBL) model supported by the Android application ClimateClass in developing students' science literacy skills. Science literacy is crucial in the 21st century as it equips students with the necessary skills to make informed decisions in a technology-influenced society. Despite Indonesia's participation in international programs like PISA, the level of science literacy in the country remains low, indicating the need for innovative educational strategies. This quasi-experimental research used a pretest-posttest non-equivalent control group design conducted at SMA Negeri 1 Padang Cermin Pesawaran with a sample of 36 students from Class X.2. The intervention involved the implementation of the PBL model with the ClimateClass application to facilitate a more interactive and problem-solving-focused learning environment. Data were collected using a science literacy test and a questionnaire and analyzed using ANCOVA to determine the significance of the intervention. The results showed that the use of the PBL model supported by the ClimateClass application significantly developed students' science literacy, particularly in identifying scientific issues, explaining scientific phenomena, and using scientific evidence. Moreover, the study found no significant differences in science literacy achievement between male and female students, indicating that gender does not affect learning outcomes in this context. These findings highlight the potential of integrating digital media into educational models to create an equitable and effective learning environment in the digital era.

Keywords: climateclass application, gender, problem based learning (pbl), scientific literacy

INTRODUCTION

Rapid advances in information and communication technology mark the era of 21st century learning. This requires the Indonesian generation to adapt and thrive in an increasingly digital society (Syahputra, 2018). Scientific literacy, as one of the 16 skills needed in the 21st century, is very important to pay attention to (S. Rahayu, 2017). Scientific literacy is not only important for understanding basic scientific concepts, but also for equipping young people with the ability to think critically and make decisions based on evidence, which is essential in a society increasingly influenced by technology and digital information (Istighfarini et al., 2022).

Education is the process of preparing students to become productive, innovative, creative, independent and successful members of society. The more ways students have to understand and integrate the information they collect, the better they will be able to use it to solve problems. In this context, science education plays an important role in creating a reliable and qualified young generation to face the challenges of the era of globalization (R. Rahayu et al., 2022). Scientific literacy is defined as the ability to use scientific knowledge, identify questions and draw conclusions based on evidence in order to understand and make decisions about the universe and make changes through human activities (OECD, 2023). This literacy allows someone to use

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scientific knowledge in making intelligent and responsible decisions, so that science education can play an active role in various aspects of life, especially in the field of science. Scientific literacy skills include the use of scientific data and evidence to assess the quality of scientific information and arguments (Huryah et al., 2017). In science learning, students are expected to have these skills and be able to apply them in everyday life (Hasasiyah et al., 2020).

Currently, the world of education is faced with serious challenges related to the low scientific literacy skills of students, a problem that needs to be addressed immediately (Kurniawati & Hidayah, 2021). For example, Indonesia, which has been part of the PISA program since 2000, still shows unsatisfactory results in terms of scientific literacy skills. Based on the 2022 PISA report, Indonesia is ranked 69th out of 81 countries that are members that are of the PISA program (OECD, 2023). The average scientific literacy score is 383 (Kemdikbud RI, 2018), showed a decrease of 13 points compared to 2018. This data shows that science literacy in Indonesia still needs to be improved.

Efforts to improve students' literacy skills can be done through learning that emphasizes scientific literacy. In addition, student-centered learning can also shape their literacy skills, by training students to use scientific knowledge, identify questions, and draw conclusions based on facts. However, questions that are often asked in the learning process tend to only emphasize the ability to remember knowledge and facts, so that students' ability to apply the knowledge gained is rarely trained. As a result, students' high-level thinking skills are less developed (Maharani et al., 2019).

The low scientific literacy skills of students in Indonesia can be influenced by several factors, including the learning model used by teachers and the materials used by students. The learning model is one of the important parts that must be considered in implementing the learning process. Several studies have shown that the application of the correct learning model can improve students' scientific literacy competencies (Wiranata et al., 2019). Problem-Based Learning (PBL) is a learning model that has been proven to have an effect on student learning outcomes (Syafriyeti et al., 2021). This model places problems and questions as the center of learning, facilitating students to solve problems using concepts. Therefore, support in the form of literacy-based tests is needed to measure students' scientific literacy when using the PBL model (Widiana et al., 2020). With this model, biology learning can shape scientific attitudes in students and encourage their active participation in maintaining environmental stability sustainably. This PBL model focuses on developing critical thinking skills, problem solving, and applying knowledge in real contexts. Students learn through practical problems that are relevant to their real lives. To solve these problems, they are directed to carry out systematic learning by searching for data from various sources (Wahyunita & Subroto, 2021).

The implementation of the PBL model will be more optimal to improve scientific literacy if it uses learning media that are familiar to students, such as Android applications. This is in line with research Istighfarini et al., (2022) which found that the use of Android-based applications significantly affects scientific literacy, digital literacy and student learning outcomes. (Munawaroh et al., 2024). Application media has its own advantages, namely being able to provide various media elements, such as text, images, videos, and animations, in the learning process, making it easier for students to gain knowledge. Research on the implementation of Android applications has also been conducted by Harianto et al., (2019) which concluded that the use of Android-based chemistry learning media can improve students' scientific literacy at a moderate level. Similar research has been conducted by (Putra & Salsabila, 2021) which shows that interactive learning media or

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multimedia is very effective in increasing students' motivation, intelligence, and cognitive skills related to literacy. If the development of learning media uses multimedia as one of its components, then the learning media will be interesting, effective, and efficient in advancing literacy culture in Indonesia. Sanusi et al., (2020) In their research, they showed that the effectiveness of Android-based learning media can improve students' scientific literacy skills in certain materials.

One of the internal factors that is seen as influencing student learning outcomes is gender. Gender is a psychosocial aspect of maleness and femaleness (Maharani et al., 2019). Gender is determined based on a number of characteristics that distinguish between masculinity and femininity. One of the characteristics that is clearly visible is gender, namely male and female. Differences in psychological aspects of men and women are often associated with factors such as intelligence, attention span, interests, talents, motivation, maturity, and readiness. These factors or gender differences will certainly affect students' learning activities and social activities. Research Isdayanti et al., (2022) shows that there are differences in learning outcomes between male and female students in the material on the structure and function of plant tissue. Meanwhile, other studies show more specific conclusions where no significant differences were found in students' critical thinking skills after using liveworksheets in learning (Wiono & Meriza, 2023). The results of this study also support the fact that male and female students do not show significant differences in argumentation skills after applying the argument-driven inquiry model (Hasnunidah & Wiono, 2019). Meanwhile, other studies have found that female students are more dominant in thinking while male students directly practice (Wiono & Dewi, 2023). Gender differences occur in several cognitive areas, such as metacognitive and critical thinking skills and problem-solving abilities (Mukti et al., 2019).

Based on the research findings above, it shows that problem-based learning has a significant influence on the development of students' scientific literacy. In addition, the use of android mobile learning (climate class) in the learning process also helps students understand knowledge because it provides features with an attractive appearance. Furthermore, the results of the study also show that boys and girls have different characteristics in learning styles and learning behaviors. So this article will examine the application of PBL assisted by android mobile learning on the scientific literacy skills of boys and girls.

METHODS

This study used a quasi-experimental method with a pretest-posttest non-equivalent control group design. In this study, one sample group was used. The independent variable studied was the Android application hereinafter referred to as Climate class, while scientific literacy skills functioned as the dependent variable. Climate class is an application specifically developed in studying the topic of climate change at the high school level. In addition, gender acts as a moderating variable. This study was conducted at SMA Negeri 1 Padang Cermin, Pesawaran, with the study population covering all 321 class X students, spread across 9 classes. The research sample was taken from class X.2 consisting of 36 students, with a composition of 14 male students and 22 female students, who were in the second semester of the 2023/2024 academic year. Before the intervention was carried out, the sample in this study was given a pretest, and after the intervention, they were given a posttest. The design of this study is shown in Table 1.

Table 1. Research Design

Pretest	Treatment	Posttest
O_1	X	O_2

Information:

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O_1 = Score Pretest both of boy and girl
X = Treatment Problem-based Learning Model assisted *Climateclass*
O_2 = Score Posttest both of boy and girl

The research instrument used was a test to measure scientific literacy skills, consisting of a pretest and posttest. This test guideline is used to evaluate student learning outcomes. The test consists of 15 multiple-choice questions. In this study, the indicators of scientific literacy competency aspects proposed by PISA are divided into three main components, which are used to collect data (OECD, 2023). These indicators are shown in Table 2.

Table 2. Competency Aspect Indicators

No	Indicators	Number	Amount
1	Identifying scientific issues	1,7,10,11,12	5
2	Explaining scientific phenomena	2,3,8,9,15	5
3	Using scientific evidence	4,5,6,13,14	5

The data analysis technique used is descriptive statistical analysis, which aims to describe the data obtained, including the lowest score, the highest score, and the average score, which are then classified into certain categories. The students who were the samples were asked to fill in the answers to the questions that had been provided in the ClimateClass application, and then the score was calculated based on the number of correct answers to each question. As for calculating the average score using the formula:

$$\text{Average} = \frac{skor\ siswa\ menjawab\ benar}{skor\ maksimum} \text{ x } 100\%$$

The students' learning outcomes are then interpreted based on their respective science literacy indicators. Which are classified into several appropriate categories (Huryah et al., 2017).

Table 3. Science Literacy Achievement Categories Based on PISA

No	Categories	Percentage
1	High	>75
2	Medium	60-75
3	Low	<60

A questionnaire consisting of 15 items, including positive and negative statements, was used to measure students' responses to the applied learning paradigm. This process aims to determine students' responses after using the PBL model supported by the ClimateClass Android application. After using the model, students were given a questionnaire to collect data. The following formula was also used to analyze the data obtained and interpreted using Table 4. according to the method described by (Arikunto et al., 2010).

Table 4. Student Response Questionnaire Categories

No	Percentage Range	Categories
1	81% - 100%	Very good
2	61% - 80%	Good
3	41% - 60%	Enough
4	21% - 40%	Not enough

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Science literacy ability data were analyzed using normality and homogeneity tests before being continued with ANCOVA tests. The normality test was conducted using the one-sample Kolmogorov-Smirnov test, and the homogeneity test was conducted using Levene's Test for Equality of Variances, each at a significance level of 5%. Data processing was carried out using the SPSS version 29 program. After the learning objectives were achieved, pretests and posttests were conducted based on gender. Variables were considered correlated if their significance value was less than 5%, and considered uncorrelated if more than 5%.

RESULTS AND DISCUSSION

The results of the study showed that there was a difference in the influence of scientific literacy achievement between students who learned using the PBL learning model assisted by the climateclass application and conventional classes. There were differences in the level of scientific literacy between male and female students after the learning process with the Climateclass-assisted PBL model. The complete results are presented in Table 5.

Table 5. Results of the Test of the Influence of Climateclass, Gender, and the Interaction of the Two on Students' Science Literacy Skills

Source	Type III Sum Of Squares	df	Mean Square	F	Sig.
Corrected model	213704568[a]	3	71234856.04	39.091	<.001
intercept	2053384510	1	2053384510	1126.829	<.001
Nilai	200380533.2	1	200380533.2	109.962	<.001
Gender	6603645.909	1	6603645.909	3.624	.061
Nilai *gender	382088.857	1	382088.857	.210	.648
error	123914183.5	68	1822267.405		
total	2552458227	72			
Corrected total	337618751.7	71			

a. R Squared = .633 (Adjusted R Squared = .617)

Based on Table 5, it is known that the 'Value' component has a significance value (sig.) of less than 0.001, which is smaller than 0.05. This shows that there is a significant influence of the application of the Climateclass-assisted PBL model on the development of students' scientific literacy skills. Furthermore, in the 'Gender' component, it can be seen that the significance value is 0.061, which is greater than 0.05. This means that there is no significant influence of gender on students' scientific literacy skills. Meanwhile, in the 'Value * Gender' component, a significance value of 0.648 was obtained, which is also greater than 0.05, indicating that the interaction between the Climateclass-assisted PBL model and gender has no effect on students' scientific literacy skills.

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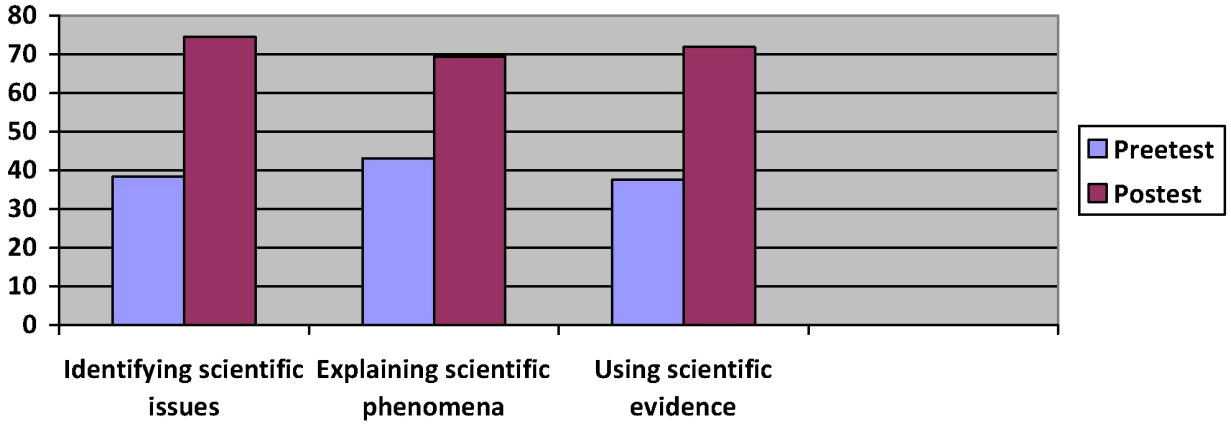

Figure 1. Average Increase in Science Literacy Ability Score

Figure 1 shows the improvement in each indicator of scientific literacy skills achieved by students in the experimental group after the application of the PBL model assisted by ClimateClass on the topic of climate change. The highest improvement was recorded in the indicator "identifying scientific issues," with a difference of 36.11, while the lowest improvement was seen in the indicator "explaining scientific phenomena," with a difference of 26.38. These results support the conclusion that scientific literacy skills are closely related to the understanding of scientific phenomena. As many as 89.21% of students gave a very good response to the use of the PBL model in topic of climate change. This shows its effectiveness not only in improving scientific literacy skills, but also in motivating students to actively participate in the learning process. The high positive response reflects that this learning method has succeeded in creating a more interactive and interesting learning atmosphere, which contributes to the achievement of optimal learning outcomes. Research by Aydoğan et al., (2022) also showed that this Android mobile learning application was effective in enhancing students' learning experience and was well received in educational contexts, as well as increasing students' awareness of climate change with significant improvements in pretest and posttest scores.

In this study, the greatest improvement occurred in the indicator "identifying scientific issues," indicating that the PBL method not only improved students' understanding of scientific content, but also their ability to recognize and identify scientific issues relevant to climate change. This finding is in line with previous research showing that a problem-based approach encourages students' engagement in identifying and analyzing scientific issues more critically (Putri et al., 2018). On the other hand, the indicator of “explaining scientific phenomena,” which is also an important aspect of scientific literacy, showed a lower increase compared to several other indicators. Research by Ashari et al., (2023) found that students' competence in "explaining scientific phenomena" was in the low category, with an average percentage of 55.15%, which was lower than several other competencies measured. This finding indicates that despite the improvement, students' ability to explain scientific phenomena still requires more attention in the implementation of the PBL model.

These findings suggest that, although students have the ability to explain scientific phenomena, improvements in this indicator are not as strong as improvements in other indicators that may be easier to master, such as “identifying scientific issues” or “using scientific data.” Therefore, more effective approaches are needed to improve students’ ability to explain scientific phenomena in greater depth.

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Table 6. Comparison of Mean Science Literacy Scores in Both Genders

No	Gender	Average of *Pretest*	Average of *Posttest*	Difference	Total Average
1	Boys	33,81	69,52	35,71	51,67
2	Girls	41,52	74,25	32,73	57,88

Based on Table 6, it can be seen that female students have a higher final score (74.25) than male students (69.52). The progress obtained by female students is also greater than that of male students, which is shown in the average total score of female students' scientific literacy skills of 6.21, higher than that of male students. However, the difference in numbers does not reach the level that gender differences affect the achievement of scientific literacy skills. This can be seen in the 'Value * Gender' component (Table 5), with a significance value of 0.648, which shows insignificant results because it is greater than 0.05.

This study indicates that gender does not have a significant effect on student learning outcomes applying the ClimateClass-assisted PBL model. Therefore, it can be concluded that gender does not affect students' achievement of scientific literacy skills. These results are consistent with the findings of previous studies by Mahanal et al., (2021), which showed that there was no significant difference in the interaction between learning models (including PBL) and gender variables on students' scientific literacy skills. This strengthens the conclusion that gender is not a significant factor in achieving scientific literacy skills. Several other abilities that are also not significantly gender biased are argumentation skills (Hasnunidah & Wiono, 2019), metacognitive awareness (Wiono & Dewi, 2023), and critical thinking (Wiono & Meriza, 2023). Observations during learning practices showed that female students appeared more accurate and credible in asking questions than male students. In addition, based on the results of student worksheets, it can be seen that female students are better able to recognize important things needed to draw conclusions, hypotheses and sort out relevant information. This is in line with the view that the part of the female brain that is related to language functions is more active than others. So this makes it easier for them to convey thoughts or ideas clearly both in writing and speech (Rafaelli & Ontai, 2004).

This strengthens the conclusion that gender is not a significant factor in achieving scientific literacy skills. The absence of a significant influence of gender on scientific literacy skills can be caused by the equal opportunities given to each student to develop their potential optimally in the learning process. Thus, gender differences do not affect students' ability to develop their scientific literacy. This is also supported by findings from Ajai & Imoko, (2016), which shows that the PBL model does not produce significant differences in academic achievement between male and female students. Equality in access to learning resources and tools in PBL allows students of both genders to compete and collaborate effectively without gender bias.

CONCLUSION

This study shows that the use of the PBL model supported by the ClimateClass Android application is effective in improving students' scientific literacy skills. The results of the statistical analysis showed a significant increase in students' scientific literacy skills after the implementation of the ClimateClass-assisted PBL model, especially in the ability to identify scientific issues, explain scientific phenomena, and use scientific evidence. In addition, these findings also indicate that there is no significant difference between the scientific literacy skills of male and female students, which means that gender does not affect the achievement of scientific literacy. This strengthens the conclusion that the PBL-based learning method supported by digital media can provide equal opportunities for all students to develop their scientific literacy optimally. Therefore, the application

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of this learning model needs to be further encouraged in the context of education to facilitate the development of 21st century skills, especially scientific literacy, in today's digital era.

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