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The Effectiveness of Problem Oriented Project Based Learning (POPBL) Towards Scientific Literacy in Public Senior High School 1 Cluring Banyuwangi

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ABSTRACT

There are various project-based learning models that can encourage scientific literacy. This study aims to analyze the effectiveness of the POPBL model in increasing high school students' scientific literacy. This quasi-experimental research used a nonequivalent control group design. The population of this study was students of eleventh graders of Science at Public Senior High School 1 Cluring, with two eleventh classes of Science 1 and Science 2 as samples. The data collection method is using scientific literacy test. The data analysis used an analysis of the covariance test. The results showed that POPBL was effective in increasing the scientific literacy of Public Senior High School 1 Cluring students. The results of the covariance analysis show a p-value of 0.023, < α (0.05). These results prove that the application of the POPBL model in the experimental class has experienced a significant increase compared to the conventional model applied in the control class. So it can be concluded that the application of the learning model POPBL is effective in increasing students' scientific literacy.

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1. INTRODUCTION

The advancement of education in the twenty-first century is currently taking place. Students today are expected to gain 21st-century learning skills, such as scientific literacy. On the other hand, the goal of science education is to help students become better at adapting to their daily lives. Scientific literacy is a person's ability to be involved with issues related to scientific thinking as a reflection in society. Someone who is scientifically literate will be happy to be involved in activities related to science and technology with the ability to scientifically describe events, evaluate and compile scientific investigations, as well as interpret data and evidence scientifically (OECD, 2019). In the field of science, scientific literacy is defined as a set of competencies mastered by someone who is scientifically literate (Leite & Bonamino, 2021).

It is crucial for students to have good scientific literacy skills to adapt to the environment, health, economy, modern social structure, and available technology (Pratiwi *et al.*, 2019). If scientific literacy is implemented, students will find it simpler to comprehend scientific ideas, acquire science process skills, and apply them in society (Utami & Senam, 2021). Therefore, applying and empowering students' scientific literacy in every biology lesson is important. Because biological material is abstract and has important terms that students must understand, it requires understanding that must also be linked to phenomena that occur in the environment. Thus, it is very important for students to have scientific literacy skills. People who have knowledge of science are willing to participate in reasoned scientific and technological discourse, which requires competence in explaining phenomena scientifically, evaluating and designing scientific investigations, and being able to interpret data and evidence scientifically (OECD, 2022)

According to the fisrt until the last PISA assessment in 2022 to seventh to twelve students aged 15, Indonesian students' scientific literacy skill was included in the low category (Romli et al., 2024). Indonesia occupies the 10th position from the bottom of the 79 countries participating in the PISA 2018. Research by Angraini (2014) claimed that a lack of comprehension of key concepts is the root of low scientific literacy.

Students struggle with discursive questions because they are not accustomed to them. Moreover, learning activities do not empower students' scientific literacy skills.

Based on the results of the initial data obtained, the mean value of scientific literacy of Public Senior High School 1 Cluring students was 58.47 and included in the medium category. It is in line with the research of Ismail et al. (2016) viewed from a value standpoint. The result of that research proved that students need scientific literacy improvement. It becomes a reason why this research was conducted in this school.

There are several ways to be done to empower scientific literacy skills, and one of them is through teachers' learning strategies. It can be applied in biology lessons (Wicaksono et al., 2019). In fact, the chosen learning model is ineffective in increasing students' scientific literacy skills. Research by Lendeon & Poluakan (2020) stated that conventional learning tends to make students feel bored since it is teacher-centered. The results of other studies also stated that the learning applied by the teacher was still unable to empower students' skills. Based on these problems, project-oriented problem-based learning will be designed, which is called Problem Oriented Project Based Learning (POPBL).

POPBL is a learning model that focuses on the problem and is project-based (Setiarini & Wulan, 2021). The learning process in this student-centered learning paradigm encourages critical and creative thinking by analyzing the material acquired to address possible difficulties (Hernandez et al., 2015). This type of Problem Oriented Project Based Learning learning model is also very suitable for empowering students in scientific literacy (Permanasari & Fitriani, 2016) and communication (Wan Husin et al., 2016). The POPBl model emphasizes three principles of learning theory, namely cognitive, collaborative and content learning (Latada & Kassim, 2017). Thus, the implementation of project-based learning is in line with the current curriculum, which is called the independent curriculum *(Kurikulum Merdeka)*.

This independent curriculum was initiated to solve the problems of learning in post-pandemic. In addition, this curriculum was implemented to overcome the recovery of learning loss that happened during a pandemic. Students need to plan and conduct the project when it is implemented in biology learning. Hopefully, students will have the opportunity to maximize their abilities and potential once the project is implemented (Saraswati *et al.*, 2022). The content presented when using the independent curriculum is easier to understand and in-depth, concentrating exclusively on the essential details. The POPBL model's presence is consistent with the idea of an independent curriculum that highlights the project while remaining in the context of the learning material.

Furthermore, POPBL is very significant to learning activities that are long-term, interdisciplinary, and student-centered (Alwi & Hussin, 2018). It is also one of the perfectly implemented pedagogy models in this era since it can boost students' 21st century skills and abilities (Ibrahim & Halim, 2013; Wan Husin et al., 2016). The POPBL learning tools developed include the Learning Objectives Lines (ATP) and modules teaching plant tissue structure as well as animal tissue structure related to contextual problems. Thus, according to the explanation above, the learning tools created for the POPBL model are intended to evaluate how well it improves students' scientific literacy.

2. RESEARCH METHOD

This research is quantitatively studied by using a quasi-experimental with a non-equivalent control group design. There were control and experimental groups. The control group was treated conventionally, and the Problem Oriented Project Based Learning (POPBL) learning model treated the experimental group. This research was conducted from August to September 2022. The research was conducted on two materials, namely plant tissue structure material and animal tissue structure material. In addition, the population was all students of eleventh-grade of science classes at Public Senior High School 1 Cluring (175 students), and the sample was the students from Science 1 and Science 2 classes (70 students). It was taken by system random sampling technique through a class equality test in which every member of the population has an equal chance of being selected (Leddy & Ormrod, 2018).

Furthermore, the data was collected by the test technique. The instrument used was a scientific literacy test consisting of 5 test items. It was designed and adjusted with the scientific literacy indicator. The indicators of scientific literacy are understanding and explaining scientific phenomena, designing and evaluating scientific investigations, interpreting data and evidence scientifically, drawing conclusions based on quantitative data, and applying knowledge in everyday life (Fives et al., 2014; Gormally et al., 2012; OECD, 2015). Additionally, this research used POPBL learning tools, including learning goal lines (ATP) and teaching modules containing handouts, student worksheets (LKPD), and scientific literacy test instruments. Following the development, learning practitioners, material experts, and learning expert validators evaluate the Problem Oriented Project Based Learning (POPBL) learning tools. The POPBL learning tool has been considered valid based on the findings of the validation that has been done. The collected quantitatve data was examined using the Covariance Analysis (Ancova) method, which was validated using the SPSS statistical package's requirements for normality and homogeneity tests.

3. RESULT AND DISCUSSION

The goal of learning science is to solve contextual problems by applying science concepts. In other words, scientific literacy is needed in the development of the 21st century. It proved that POPBL is effective in enhancing students' scientific literacy. It can compare with the control class, which used a traditional model of learning. The implemented POPBL learning model has an essential role in supporting the improvement of each indicator by scientific literacy. On the other hand, some indicators of scientific literacy include understanding and explaining scientific phenomena, designing and evaluating scientific investigations, interpreting data and evidence scientifically, drawing conclusions based on quantitative data, and applying knowledge in everyday life (Fives et al., 2014; Gormally et al., 2012; OECD, 2015). Scientific literacy data were obtained from the scientific literacy test (5 questions). The five questions came from five indicators of scientific literacy which have previously been tested for their validity and reliability. The results of the validity and reliability tests of scientific literacy questions are in Table 1.

Table 1. Validity and Reliability Results of Scientific Literacy Test

Number of Question	Sig Value (2-tailed)	Description	Cronbach Alpha Score	r-tabel Score (N=70)	Description
1.	.000	Valid	0,648	0,2319	Reliable
2.	.000	Valid	0,639		Reliable
3.	.000	Valid	0,488		Reliable
4.	.000	Valid	0,471		Reliable
5.	.000	Valid	0,646		Reliable

Table 1 it showed that questions that have been developed are valid with sig values > r-table values, and these questions are also classified as reliable in the medium category with Corbanch Alpha value (> 0.04) to high (> 0.6). Moreover, questions that have been declared valid and reliable are then tested on students. Based on the results of the scientific literacy research data that has been obtained, the data is tested using the prerequisite test with the following results in Table 1.

Table 2. Test Results for Normality and Homogeneity of Science Literacy Data

Descriptive Statistics					
Class	**Mean**	**Std. Deviation**	**N**	***Asymp.Sig* Value (0.200)**	***Levene's* Test.Sig Value**
Experiment	76.5080	9.59370	35	0.200	0.691
Control	70.6603	11.29973	35		

The result of the normality test in Table 2 proved that the data on students' scientific literacy was normally distributed. Moreover, the sample result of the Kolmogorov-Smirnov Final Test was Asymp sig. (2-tailed) = 0,200>0,05, which means that the distribution of scientific literacy data is normally distributed and does not deviate. After that, it was continued to test the homogeneity by using *Levene's Test of Equality of Error Variances*, as seen in Table 2. It was displayed that the scientific literacy data was homogeneous (Levene's test 0,691>0,05). In addition, the graph of the increase in the average score of scientific literacy can be seen in Figure 1.

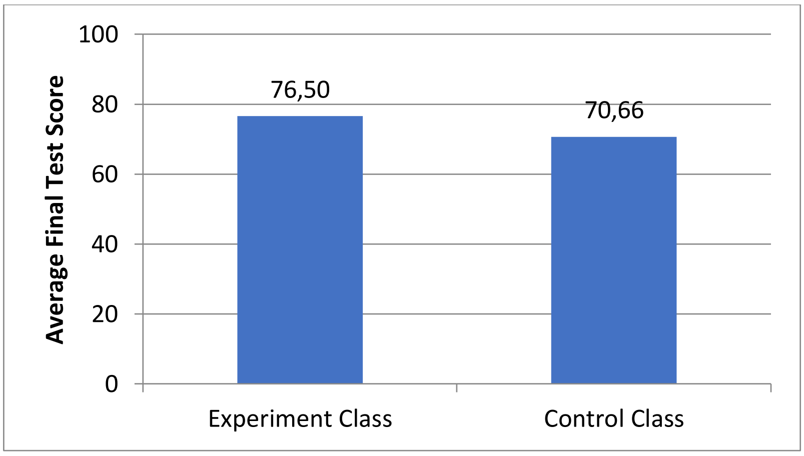

Figure 1. Graphs of Scientific Literacy Abilities of the Control and Experiment Class

Based on Figure 1, the average score graph showed that the average score of the final test in the experiment class increased by 76.50 by using the POPBL learning model. However, the control class got 70.66 for the average score by implementing a conventional learning model. Thus, it was shown that the POPBL learning model is effectively implemented to increase students' scientific literacy. The enhancement was caused by the treatment of the POPBL learning model, which influenced each indicator of scientific literacy. The POPBL learning model employed three principal theories; cognitive, collaborative, and content learning (Latada & Kassim, 2017). Moreover, four phases in the POPBL learning model include 1) orientating and formulating the problem, 2) organizing students to learn, 3) planning and doing the project, and 4) presenting the result and project evaluation (Rongbutsri, 2017; Yasin & Rahman, 2011).

Further, there are four phases of the POPBL model. The first phase is problem orientation and formulation. In this phase, students are faced with the triggered problem to be solved. It can be done by choosing one of the essential problems formulated for the theme. This phase project will help improve the first indicator of scientific literacy, namely understanding and explaining phenomena. Based on Wulandari & Sholihin (2016), in a formulating activity, students are expected to be sensitive to the current issues in science, able to identify the question and interpret the scientific phenomena from a problem scientifically. In this phase, the students can build their knowledge and concept through investigation and new experienced acquired. This statement aligns with the Constructivism theory of J. Bruner asserts that students can easily understand a delivered learning material to find the concept and formulate the problem based on their new insight. Additionally, Bruner also claimed that learning is a process of understanding a concept, and learning is the ability to solve a problem (Stapleton & Stefaniak, 2019). It is in line with the research of Saputra (2020) stated that problem-based learning generally serves the contextual problem in life as a trigger to the student's learning process before studying the concept.

The second phase is organizing the students to explore the knowledge of a certain problem (topic) from several resources. Afterward, students can write the important concept related to the chosen problem in points, resumes, or mind mapping. This phase will increase the quality of each indicator to plan and evaluate the scientific investigation. This statement is in line with Piaget's cognitive learning theory, which states that the processes of assimilation and accommodation in student learning mutually support one another. In assimilation, a person's cognitive ability can integrate new perceptions, concepts or experiences and process thoughts with a combination of previously owned concepts. While the accommodation of the formation of new knowledge by changing old knowledge that is adapted to the relevant surrounding problems (Setiawan, 2017). It is in line with the research of Eliyawati et al. (2020), who claimed that POPBL learning helps maximize concept mastery and scientific literacy of students in learning biology.

Additionally, the third phase is designing and conducting the project. Students collect any information to compile alternative solutions that will be developed into projects. This activity will improve aspects of scientific literacy, interpret data and evidence scientifically, and draw conclusions based on quantitative data. The project plan is prepared including 1) title; 2) aims and objectives; 3) method or method of work; 4) expected results (product or action plan). At this stage, students can design knowledge based on their own concepts through investigations and new experiences gained. This statement is in accordance with constructivist learning theory by J. Bruner, stating that students easily understand the material by learning to find concepts and can transfer knowledge in new ways. Bruner also views learning as a process of learning concepts and the ability to solve problems (Stapleton & Stefaniak, 2019).

Moreover, the last phase is presenting the results and evaluation. In this stage, students presented their project results and conducted the evaluation together. This activity is carried out collaboratively and presents project results in various forms of creativity (posters, videos, application designs, action plans, etc.). This activity will improve aspects of scientific literacy by applying knowledge in everyday life. This learning model emphasizes interaction between students in working on projects and discussion activities related to solutions or projects for solving problems encountered. This statement is supported by the theory of sociocultural learning by Vygotsky, which states that learning is building a higher mental phase that occurs during interaction and cooperation. In the learning process, there will be an increase in the Zone of Proximal Development (ZPD). ZPD is a learning process that helps students to increase student skills (Nurdyansayah & Fahyuni, 2016). Further, the results of the Scientific Literacy Hypothesis Test used in Covariance Analysis are shown in Table 3.

Table 3. Ancova's One-Way Science Literacy Hypothesis Test Results

Dependent Variable: posttest

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	598.426[a]	1	598.426	5.447	.023	.074
Intercept	379023.826	1	379023.826	3450.016	.000	.981
Class	598.426	1	598.426	5.447	.023	.074

Error	7470.580	68	109.861
Total	387092.832	70	
Corrected Total	8069.006	69	

a. R Squared = .074 (Adjusted R Squared = .061)

From the results of the hypothesis test using Covariance Analysis in Table 3, it can be seen the p-value 0,023, < α (0,05), consequently, it was concluded that the experimental class, which follows the POPBL model and the control class, which follows the conventional model, have different levels of student proficiency in scientific literacy. Research results have proven that the POPBL model is effective for increasing the scientific literacy of students in Public Senior High School 1 Cluring. Furthermore, a learning theory underlies the syntax stages of the POPBL learning model that has been described. The basic theory of the POPBL model uses a constructivist sociocultural approach (Yasin & Rahman, 2011). This statement is supported by the learning theory by Vygotsky and J. Burner, which declared learning as a process for learning concepts and the ability to solve problems. Then, students also learn to build mental phases when communicating or working together. In this learning process, there will be an increase in their ZPD (Nurdyansayah & Fahyuni, 2016; Stapleton & Stefaniak, 2019).

The POPBL learning model is seen as a potential approach to promoting sustainable development, assuming that graduates will learn better when what is learned is meaningful, relates to real-life conditions, and allows students to be directly involved (Yasin & Rahman, 2011). Further, the scientific literacy skills assisted by the POPBL learning model can improve other 21st Century skills, such as cultivating students in critical thinking and creative thinking as well as communication skills and problem-solving through project-based activities (Yasin & Rahman, 2011; Wan Husin et al., 2016). in other words, the existing aspects of scientific literacy have been able to support students in increasing the demands of current skills. The advantages of the POPBL model are problem-oriented project-based learning with project work in groups, and active, participatory learning types, directed in dialogue between students and teachers as facilitators or supervisors.

4. CONCLUSION

Based on the results of data analysis and discussion, it can be concluded that the POPBL learning model applied in the experimental class can improve students' scientific literacy abilities compared to the control class, which only uses the conventional model with scientific literacy abilities below the experimental class.This increase is due to each learning phase of the POPBL model, which can influence the increase in each student's scientific literacy indicator. Thus, the application of the POPBL learning model has proven effective in increasing students' scientific literacy.

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