Application of The PjBL Model to Train Science Literacy Skills of High School Students on the Subject of Alternative Energy

Putri Indah Ramadhani[1], Rif'ati Dina Handayani[1]*, Lailatul Nuraini[1], and Leizy Free Agustin F.[2]

[1]Department of Physics Education, Faculty of Teacher Training and Education, University of Jember, Jember, Indonesia
[2]SMA Negeri 5 Jember, Jember, Indonesia
*rifati.fkip@unej.ac.id

Abstract

The development of science and technology in the era of the Industrial Revolution 4.0 requires everyone to master 21st-century skills, one of which is science literacy. Science literacy skills in Indonesia are still relatively low. Students' low science literacy skills are caused by several factors: the selection of learning models, teaching materials, and non-contextual learning. This study aims to describe the application of the PjBL model to train high school students' science literacy skills on the subject of alternative energy. This research uses descriptive qualitative research. The sampling technique in this study used a purposive sampling technique. The research instruments used in this study were observation sheets for implementing the learning model and student worksheets. The qualitative data analysis technique used in this research is a case study. The results showed that implementing learning conducted in groups could make students active in solving problems. Each group actively participated in answering student worksheets and completing projects by analyzing and making alternative solutions to the problems presented. The stages in the student worksheet following the PjBL model can shape the science literacy skills of high school students. This study's conclusion shows that applying the PjBL model trains students' science literacy skills. While applying the PjBL model, researchers directed each group to carry out project activities through the learning stages of the PjBL model. Each group was able to identify and provide solutions to problems, design product plans, develop schedules, make simple projects following the design, test the results, and make conclusions.
Keywords: Alternative energy; PjBL model; Science literacy skills

INTRODUCTION

Science and technology are developing rapidly in the era of the Industrial Revolution 4.0 in the 21st century. This condition requires everyone to master 21st-century skills, including science literacy. Science literacy is a person's ability to apply science concepts in everyday life by explaining and describing scientific phenomena based on scientific evidence (Fuadi et al., 2020). Without science literacy, a person

will have difficulty solving problems related to education, science, and social problems encountered in everyday life (Alatas & Fauziah, 2020; Sutiani et al., 2021). Based on this understanding, students' science literacy skills are needed in learning.

Students' science literacy skills are needed to face the challenges of the 21st century. Sari et al. (2023) stated that 50.79% of students had difficulty explaining scientific phenomena, 61.90% had difficulty evaluating and designing scientific investigations, and 80.95% had difficulty interpreting data and providing scientific evidence. Based on the evaluation results by the International Organisation for Economic Cooperation and Development (OECD) through PISA, the science literacy skills of students in Indonesia are always ranked low. Based on PISA 2018 data, Indonesia ranks 69th out of 78 participating countries with a student science literacy score 396 (Schleicher, 2019). These data show that the science literacy skills of students in Indonesia are still relatively low. The low level of students' science literacy skills is one of the educational problems in Indonesia.

Based on the results of preliminary observations through interviews that have been conducted by researchers with physics subject teachers in class X SMA Negeri 5 Jember, class X students have diverse characters and abilities. Some students are active or silent when given physics problems. Teachers still need to train students' science literacy skills.

Several factors influence students' low science literacy skills. Sari et al. (2023) argued that the factors that cause low student science literacy are the selection of learning models and teaching materials. Suparya et al. (2022) stated that students' low science literacy skills are caused by non-contextualised learning. The implementation of non-contextualized learning causes students in Indonesia to be unable to link the

understanding of the science they learn with phenomena that occur in the world.

Project-based learning is one of the learning models implemented in the Merdeka Curriculum. Fahlevi (2022) stated that applying the PjBL model is one of the priority programs in the Merdeka Curriculum, which offers relevant and interactive learning. Learning using the PjBL model can improve learning abilities, self-confidence, and independence, and students are more creative and innovative in developing the fields of knowledge they learn (Nugrohadi & Anwar, 2022). Khoiriyah et al. (2023) and Wijayanto et al. (2020) argue that students better understand the concept of material through PjBL model learning. The PjBL model is one of the appropriate models for learning the Merdeka curriculum because it follows the learning recovery objectives.

The PjBL model is a learning strategy involving students working on a useful project for solving problems. Rizkamariana et al. (2019) argued that the project-based learning (PjBL) model improved the science literacy skills of high school students. Munawarah et al. (2023) stated that learning using the PjBL model provides opportunities for students to learn to solve problems. The PjBL model helps students create their knowledge based on the findings during the project (Balemen & Özer Keskin, 2018; Venalia et al., 2022; Zarte et al., 2020). Learning using the PjBL model results in a project so that students can make connections between learning experiences in school and real life.

One of the physics materials that can be used to apply the PjBL model is alternative energy, commonly known as renewable energy. Mudhofir et al. (2022) said that students' knowledge about the utilization and future of energy is an important study because students will better understand and solve environmental problems, especially

those related to energy sources. Dinantika et al. (2019) concluded that the project-based learning model greatly increases student creativity on renewable energy material. The PjBL model produces a product that can be used as a student learning resource. The existence of student projects carried out by students, students will better understand and solve environmental problems, especially those related to energy sources, so that students can develop science literacy skills.

Students' science literacy skills in Indonesia are low. The low science literacy of students is caused by several factors, namely the selection of learning models, the use of learning resources, and non-contextual learning. Based on these factors, this research discusses applying the PjBL model to train the science literacy skills of high school students on the subject of alternative energy.

METHOD

This research uses descriptive qualitative research. Qualitative descriptive research is a form of research in which the description uses facts obtained from the data as they are (Nanny et al., 2023). This research was conducted at SMA Negeri on 5 Jember in the even semester of the 2022/2023 school year, precisely from 15 February 2023 to 1 March 2023, for three meetings. The population in this study were grade X students of SMA Negeri 5 Jember. The sampling technique in this study used a purposive sampling technique. The sample of this study was class X-2 students of SMA Negeri 5 Jember with a sample size of 35 students.

The research instruments used in this study were observation sheets for implementing the learning model and student worksheets. The observation sheet for the implementation of the learning model used contains the stages of the PjBL model carried out by the researcher during the learning process. The learning stages used in the learning

model implementation observation sheet are eight stages adjusted based on the PjBL model syntax. Meanwhile, the student worksheet used in this study is a group student worksheet based on the PjBL model case study associated with science literacy on alternative energy.

The application of the PjBL model was analyzed using the percentage of the results of the learning implementation observation sheet and the answers to the student worksheets. Jamaluddin *et al.* (2020) stated that the analysis of literacy skills in applying the PjBL model was formulated using Equation 1.

$$final\ score = \frac{gain\ score}{maximum\ score} \times 100 \qquad (1)$$

The application of the PjBL model is determined based on the category of the implementation of the learning model as in Table 1.

Table 1 Categories of learning model implementation

Score Interval	Category
$84 < x \leq 100$	Very well done
$67 < x \leq 84$	Well done
$50 < x \leq 67$	Enough done
$33 < x \leq 50$	Less implemented
$0 \leq 33$	Not Implemented

(Jamaluddin et al., 2020)

RESULT AND DISCUSSION

The research was conducted by applying the PjBL model to measure the science literacy skills of high school students on the subject of alternative energy. This study's participants were 35 students who were divided into six groups. The research data were obtained from the analysis of observation sheets of the implementation of the learning model and answers to student worksheets. The data from the research results were arranged in tables and descriptions of student worksheet answers.

Three observers conducted observation of the implementation of the learning model. The recapitulation of the results of the observation of the implementation of the learning model is

shown in Table 2.

Table 2 Recapitulation of observation results of the implementation of the learning model

No.	Learning Stages	Average Achievement Score
1	Introduction	5
2	Fundamental Question	3
3	Designing Project Planning	1
4	Developing a Schedule	1
5	Monitoring Project Activity and Progress	2
6	Testing Results	2
7	Evaluation of Learning Experience	3
8	Cover	3
Total Average Earned Score		20
Value		95.24
Category		Very well done

Table 2 shows the recapitulation of the observation results of implementing the learning model conducted by three observers. Based on Table 2. the implementation of the learning model that has been carried out is included in the category of very well implemented.

The recapitulation of the group student worksheet assessment results is shown in Table 3.

Table 3 Recapitulation of student worksheet assessment results

PjBL Model Syntax	Number of Groups			
	Less good	Good enough	Good	Very good
Fundamental Question	0	2	3	1
Designing Product Planning	0	1	3	2
Developing a Schedule	0	1	2	3
Monitoring Project Activity and Progress	0	0	3	3
Testing Results	0	0	2	4
Evaluation of Learning Outcomes	0	0	3	3

Fundamental Question
The fundamental question stage directs students to explain the problem and provide alternative solutions according to the reading in the article presented in the student worksheet. Based on the answers to the student worksheets, the two groups were good at identifying and providing alternative solutions to the problems.

Three groups were good at identifying problems and providing multiple alternatives to the problems presented. One group was very good at explaining and providing detailed alternative solutions to the problems presented. Examples of student worksheet answers at the fundamental question stage are shown in Figure 1.
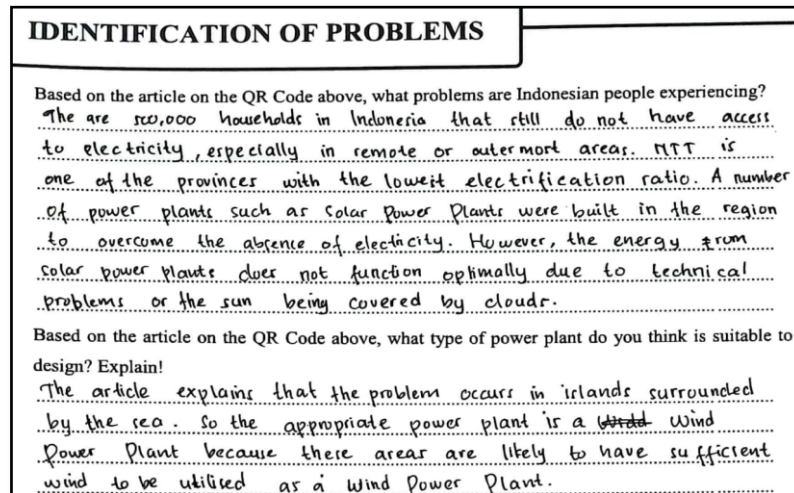
IDENTIFICATION OF PROBLEMS

Based on the article on the QR Code above, what problems are Indonesian people experiencing?
The are 500,000 households in Indonesia that still do not have access to electricity, especially in remote or outermost areas. NTT is one of the provinces with the lowest electrification ratio. A number of power plants such as Solar Power Plants were built in the region to overcome the absence of electricity. However, the energy from solar power plants does not function optimally due to technical problems or the sun being covered by clouds.

Based on the article on the QR Code above, what type of power plant do you think is suitable to design? Explain!
The article explains that the problem occurs in islands surrounded by the sea. So the appropriate power plant is a ~~Wind~~ Wind Power Plant because these areas are likely to have sufficient wind to be utilised as a Wind Power Plant.

Figure 1 Example of student worksheet answers at the fundamental question stage

Designing Product Planning

The stage of designing product planning directs students to determine what factors need to be considered in planning the manufacture of products according to the chosen solution. Based on the answers to the student worksheets, the two groups are very good at identifying the factors that must be considered in making the simple power plant to be made. The two groups identified the factors that must be considered in making the simple power plant in great detail, and based on these factors, they were able to design the project neatly and measurably. Three groups were good at identifying the factors that must be considered in making a simple power plant and were able to design the project design. One other group did not explain in detail the factors that must be considered in making the simple power plant that will be selected. An example of a project design made by one of the groups is shown in Figure 2.
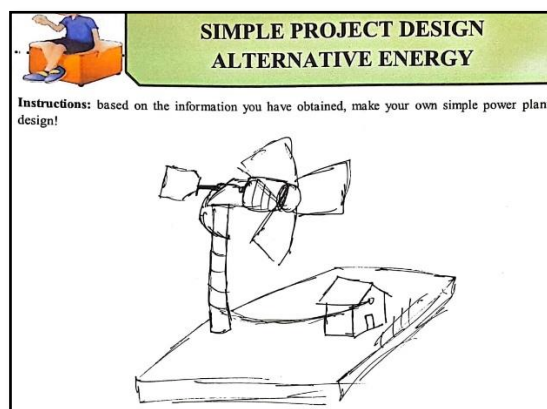

Figure 2 Example of student worksheet answers at the project planning design stage

Developing a Schedule

The schedule stage directs each group to compile and calculate the time needed for product manufacturing. Each group should prepare a schedule by estimating how much time is needed to carry out each step of the product manufacturing. Based on the answers to the student worksheets, the three groups were very good at making project schedules by estimating the time required to complete the project. Two other groups were good

at making project schedules. One group was quite good at preparing the schedule but could not make a schedule with a good time estimation. Examples of students' worksheet answers in preparing the schedule areshown in Figure 3.

Figure 3 Example of student worksheet answers at the stage of compiling a schedule

Monitoring Project Activity and Progress

The stage of monitoring the activity and development of the project directs all groups to make the project according to the schedule and discuss any problems that arise during the completion of the project. The projects made by each group had different models. Three groups were very good at carrying out project activities following the steps of making and design that had been designed. The other three groups were good at making simple projects according to the steps, but the project design was not under the design that had been prepared. The difference between the design and the project results that have been made is that during the making of the project, there were several obstacles, so the making of the project did not follow the design that each group had made. Examples of project results that students have made are shown in Figure 4.

(a)

(b)

Figure 4 Example of project results

Testing Results

Each group was asked to explain the results of the project that had been made. Each group's simple wind farm produced electricity, as evidenced by the LED lights' life. Four groups were very good at testing the project's results, which was marked by a project that produced electricity and bright LED lights. Two groups tested the project results well, but the LED lights were less bright. Based on the results of measuring the voltage produced by the simple wind farm that all groups made, the electricity produced was different. Examples of student worksheet answers at the stage of testing the results are shown in Figure 5.
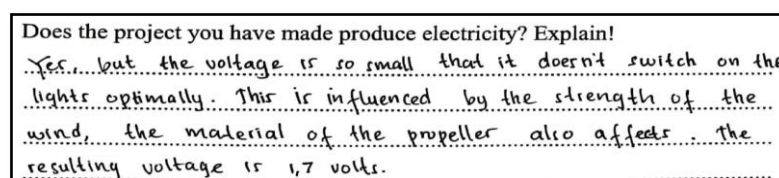

Figure 5 Example of student worksheet answers at the stage of testing results

Evaluation of Learning Experience

The evaluation stage of the learning experience directs each group to explain the project results based on the desired expectations. Based on the answers to the student worksheets, the three groups were very good at evaluating the obstacles faced and concluding the project results. The other three groups were good at conveying the obstacles and briefly summarising the project results. Examples of student worksheet answers at the learning experience evaluation stage are shown in Figure 6.
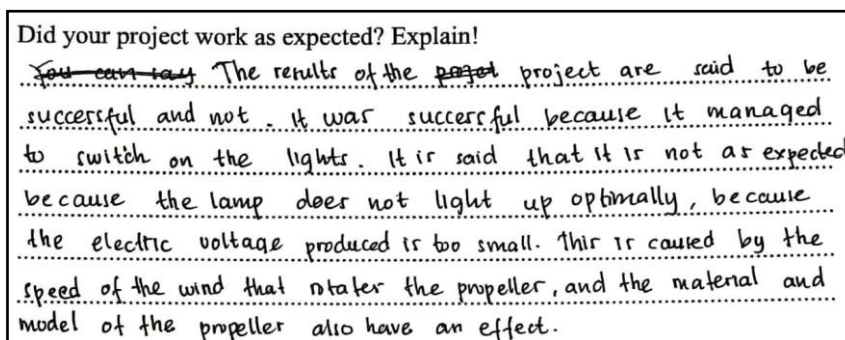

Figure 6 Example of student worksheet answers at the learning experience evaluation stage

The PjBL model, in its implementation, has six stages. Each stage is expected to support the achievement of the desired learning objectives. Based on the observation results, learning using the PjBL model carried out by researchers has been carried out very well. Researchers have carried out the PjBL model stages, from the introduction to the closing. However, the researcher did not ask students to pray in the closing stage. When the learning ended, the researcher did not ask students to pray because the subject teacher would continue the learning in the next hour. The implementation of learning carried out by researchers is very well done because researchers have carried out learning with the stages in the PjBL model. These results are supported by research conducted by Rizkamariana et al. (2019), which states that the percentage of implementation of each stage of PjBL *is in a* good category

because teachers and students can learn following the syntax of the PjBL model.

The implementation of learning by researchers was also carried out very well because students followed the learning according to the stages in the PjBL model. Students are asked to work on student worksheets in groups during the learning process. The student worksheet used by students is based on the PjBL model, so all questions on the student worksheet are related to the stages in the PjBL model. The first stage contained in the student worksheet is the fundamental question stage. Before working on the student worksheet, the researcher showed a video about the energy crisis that hit the world. The researcher linked the video shown with Indonesia's energy sources condition. Next, the researcher directed students to identify the problems in the student worksheet. Each group identified the problems presented and provided solutions to these problems. Each group's answers showed a good understanding of recognizing the core and detailed problems. The purpose of identifying problems is so that students can recognize problems well and design solutions that can be done to solve these problems. Problems related to real life can train students' science literacy skills. In line with Wang & Wang's (2023) research, group discussions about energy problems associated with real life make students have a better view of energy. Özbay and Duyar (2022) also stated that developing alternative energy policies must ensure a sustainable environment and future.

The second stage contained in student worksheet is designing a product plan. The researcher directs students to find relevant information about the factors that must be considered in making simple power plants that each group has selected. Each group identified the factors that must be considered in making a simple power plant to solve the problem. Each group designs a project

using the waste around them based on these factors. Based on the answers to the student worksheets, each group was able to design the project planning well. This study's results align with the research of Santos et al. (2023), who stated that project-based learning can build students' competence in project management and scientific evidence processing.

The third stage contained in the student worksheet is preparing a schedule. The researcher informed the students about the time limit for making the project. The researcher directed the students to compile the manufacturing steps by estimating the time needed to make the project. Each group compiled a schedule with an estimated time according to the steps of making the project. Each group was able to complete the project within two class hours. Although the schedule for each step was not what had been planned, the project did not exceed the planned time estimate.

The fourth stage contained in the student worksheet is the stage of monitoring the activeness and development of the project. Researchers monitored students' activities in making projects. Each group made the project following the steps that had been prepared. During the project's making, several problems occurred, such as propellers that could not rotate properly and the project not producing electricity. The researcher directed students to find out the cause of the problem. The researcher directed students in groups to discuss and find alternative solutions as problem-solving. Each group solved the problem according to the researcher's direction. These results are based on Gomez-del Rio & Rodriguez (2022) research, which states that project-based learning can integrate students' knowledge.

The fifth stage contained in the student worksheet is the stage of testing the results. The researcher taught students how to use a multimeter to

measure the amount of electricity generated. Each group actively learned how to use a multimeter so that each group could test the project results well. Each group could test the project results independently using the multimeter provided by the researcher. Each group was also able to show that the project that had been made was successful according to the plan, both in brief and in detail. The success of the project results is shown by the results of electrical measurements using a multimeter and the LED lights on the project.

The sixth stage in the student worksheet is the evaluation stage of the learning experience. The researcher directed each group to evaluate the results of the project that had been made. Each group could evaluate the project results that had been made briefly and in detail. Although the speed of the fan used as support in testing the project was very small, each group was able to conclude that wind speed and propeller shape can affect the electricity generated.

Based on the stages carried out, researchers direct students during learning using the PjBL model, and each group has been able to create projects, discuss problems experienced, and evaluate the resulting projects. This is supported by research by Kurniawati et al. (2021) that shows that PjBL model learning can train students to design and conduct experiments to create a product. Students are encouraged to have many discussions to find new information according to the answers (Aranzabal et al., 2022; Dywan & Airlanda, 2020). These results are also reinforced by the research of Nugrohadi & Anwar (2022), who found that PjBL model learning teaches students to work together independently by motivating them to complete it well.

Implementing learning conducted in groups can make students active in solving problems. Each group actively participated in answering student worksheets and completing projects by analyzing and making alternative solutions to the problems presented. These results follow the research of Stoeva & Stoev (2022), which states that when working on projects, students work as a group to actively and creatively build their knowledge based on their experiences and interactions with the environment by searching and analyzing information, conducting and developing research independently.

Student worksheets help students practice explaining phenomena scientifically, interpreting data and evidence, and evaluating and designing scientific investigations. The stages in the student worksheet that follow the PjBL model can shape the science literacy skills of high school students. These results are by the research of Anggreni et al. (2020), which states that the PjBL model assisted by portfolio assessment affects students' science literacy because the PjBL model involves students actively participating in project activities to be able to identify scientific issues and explain scientific evidence so that it can form science literacy skills.

Based on the research results, applying the PjBL model to train high school students' science literacy skills has been carried out very well. While applying the PjBL model, researchers directed each group to carry out project activities following the learning stages of the PjBL model. Each group was able to identify and provide solutions to problems, design product plans, develop schedules, do simple projects under the design, test the results, and make conclusions. Based on these results, it can be concluded that applying the PjBL model trains students' science literacy skills. This conclusion is reinforced by the research of Khotimah et al. (2020) that the PjBL model affects students' scientific literacy as shown during the process of making projects until finally, students can complete them and answers

from students when presenting the projects that have been made. Karademir and Ulucinar (2017) also stated that science literacy skills contribute to argumentation-based activities in the context of science education.

This study has an obstacle: the lack of alternative solutions students use to solve problems. Five out of six groups made a solution using a simple wind power plant. The solution was chosen because the learning aims to make a simple power plant from surrounding waste. The wind power plant was used as an alternative solution because it is under the wind potential in Indonesia and has a low cost. Another obstacle in this research is that the electricity generated by simple power plants is very small. This is due to the limited speed of the fan used to test the project results. Therefore, future research is expected to not give limitations in the use of project materials so that the solutions provided are more varied and provide the necessary materials and tools to explore alternative solutions made by students.

CONCLUSION

The application of the PjBL model to train high school students' science literacy skills can be carried out very well. While applying the PjBL model, the researcher directed each group to carry out project activities following the learning stages of the PjBL model. Each group was able to identify and provide solutions to problems, design product plans, develop schedules, do simple projects under the design, test the results, and make conclusions. Thus it can be concluded that applying the PjBL model can train the science literacy skills of high school students on the subject of alternative energy.

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