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Application of the PjBL-STEM Model to Improve Science Literacy of Class XI SMAN Plus Student

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Abstract: *This research aims to improve students' scientific literacy skills by using the Project-based learning (PjBL) learning model integrated with the STEM (science, technology, engineering, and mathematics) approach in class XI MS 3 students at SMAN Plus, Riau Province. The research used the Classroom Action Research (PTK) method with a total of 29 students, which was carried out in two cycles, with each PTK cycle consisting of five steps, namely: 1) localizing the problem, 2) planning, 3) action and observation, 4) analyzing data, and 5) reflection. The scientific literacy studied includes 3 competencies, namely explaining phenomena, interpreting, evaluating, and designing scientific investigations. The results of the analysis of students' scientific literacy abilities from the comparison of cycle I and cycle II showed an increase in scientific literacy scores, namely from 64.3 to 72.1. Based on the research results, it can be concluded that the application of the PjBL-STEM learning model is effective in improving students' scientific literacy skills in learning Physics, especially in class XI MS 3 SMA Plus Pekanbaru.*

Keywords*: classroom action research, physics learning, Project-Based Learning-STEM, science literacy.*

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Penerapan Model PjBL-STEM untuk Meningkatkan Literasi Sains Siswa Kelas XI SMAN Plus

Abstrak: Tujuan dari penelitian ini yaitu untuk meningkatkan kemampuan literasi sains siswa dengan menggunakan model *Project based learning* (PjBL) terintegrasi pendekatan STEM (*sience, technology, engineering, and mathematics*) pada siswa kelas XI MS 3 SMAN Plus Provinsi Riau. Penelitian ini menggunakan metode Penelitian Tindakan Kelas (PTK) dengan jumlah siswa 29 orang, yang dilakukan dalam dua siklus, dengan masing-masing siklus PTK terdiri dari lima langkah yaitu: 1) melokalisasi permasalahan, 2) perencanaan, 3) tindakan dan observasi, 4) menganalisis data, dan 5) refleksi. Literasi sains yang dikaji meliputi 3 kompetensi yakni menjelaskan fenomena, menafsir, mengevaluasi dan merancang penyelidikan ilmiah. Hasil analisis terhadap kemampuan literasi sains siswa dari perbandingan siklus I dan siklus II diperoleh peningkatan skor literasi sains yaitu dari nilai 64,3 menjadi 72,1. Berdasarkan hasil penelitian dapat disimpulkan bahwa penerapan model pembelajaran PjBL-STEM dapat meningkatkan kemampuan literasi sains siswa dalam pembelajaran Fisika, khususnya di kelas XI MS 3 SMAN Plus Pekanbaru.

Kata kunci: penelitian tindakan kelas, pembelajaran fisika, Project Based Learning-STEM, literasi sains.

Introduction

Science education today mainly focuses on content mastery, disengages from the social environment, and employs improper exams to ensure that students only acquire knowledge (Sakti & Swistoro, 2021). A learning process should ideally give pupils the opportunity and understanding to apply the knowledge they have learned. Learning must be understood by students and applied to their daily lives; mastering a body of information in the form of facts, concepts, or principles is insufficient (Ardhitayasa *et al*., 2022). Science literacy is one of the competencies that must be prioritized for students to use science in the right contexts (Suryani *et al*., 2017).

A person's capacity for critical thought and interaction with scientific-related concepts and situations is known as science literacy (Sholahuddin *et al*., 2023). Another way to think about science literacy is as science literacy, either conceptually or practically. A person must be able to analyze and design research, explain phenomena, and interpret data and evidence using scientific methods in order to be considered science literate (Aulia *et al*., 2018). Pupils with strong science literacy abilities will be able to use what they've learned to address real-world issues (Jufrida *et al*., 2019). Because science literacy concepts may be applied to solve problems in real-world situations, they facilitate human activities.

The necessity for science literacy to be taught and developed in the classroom stems from its significance. The class XI MS 3 SMAN Plus Riau Province survey findings show that pupils' science literacy skills are still in the low range, at 58.5. This highlights how crucial it is to raise science literacy in physics classes. According to the most recent PISA results report from 2018, when examined through the lens of international surveys, Indonesian students' average science score is 389, with an OECD average score of 489 (OECD, 2018). This demonstrates that Indonesian pupils' average science literacy is still significantly lower than the PISA norm.

PISA results go beyond simple rankings and scores. The study's findings also include information about students' backgrounds, behaviors, and classroom teaching methods, among other things (Kemendikbud, 2019). Many educators still impart knowledge in the classroom without considering its application. On the other hand, because contextual learning integrates students' everyday lives, it is crucial for them to acquire prior information about themselves (Zulirfan *et al*., 2023). The findings of observations conducted at SMAN Plus Riau Province during the teaching assistantship program revealed that physics instruction in schools focuses mostly on conceptual knowledge, theoretical mastery, and question discussion. In the meantime, students are not trained to apply the concepts they are learning about physics because the application of the concepts is limited to one session per semester. Based on studies Syukri *et al*. (2021) the best way to address the issue of pupils' lack of science literacy is to implement a suitable learning paradigm. The project-based learning (PjBL) paradigm is thought to be the best way to solve these issues.

According to Afriana (2016), a student-centered knowledge paradigm called project-based learning gives pupils engaging educational opportunities. Certain PjBL studies can enhance the results of cognitive learning (Baran, 2010). Since project-based learning naturally incorporates a wide range of academic skills-including reading, writing, and math-and is useful for developing conceptual knowledge through the integration of several courses, it is a better fit for interdisciplinary learning (Capraro, 2013). It follows that using the PjBL paradigm should help students become more proficient in their physics classes. To ensure that learning takes place in the classroom at its best, teachers must also take into account the method being employed in addition to the learning model.

Science is frequently applied in technology, so in order to prepare students for the demanding 21st century, a different method is required. According to Stohlmann (2012) in scientific education, it is impossible to isolate the relationship between science and technology from other sciences. STEM (*Science, Technology, Engineering, and Mathematics*) are fields of study that have a close relationship with one another. Science uses arithmetic as a tool to process data, but engineering and technology are applications of science. Students are expected to learn relevant material through the methodical integration of knowledge, concepts, and abilities provided by the STEM learning methodology. Students that use the STEM approach gain from increased problem-solving skills, independence, logical thinking, and both science and technology literacy (Sasmita *et al*., 2021; Syukri *et al*., 2018). PjBL-STEM learning can be used to develop students' science literacy skills, foster innovative mindsets, and assist students understand the course topics.

According to the above explanation, research on the efficacy of applying the PjBL model, which is based on the STEM approach, is necessary to raise students' science literacy levels in physics classes.

Research Methods

In order to provide a supportive learning environment, this classroom action research emphasizes process development as well as the relationship between teacher teaching actions and student learning actions (Rusdi, 2020). Margaret Riel's action research paradigm, which follows the phases depicted in Figure 1, is the one utilized in the classroom.

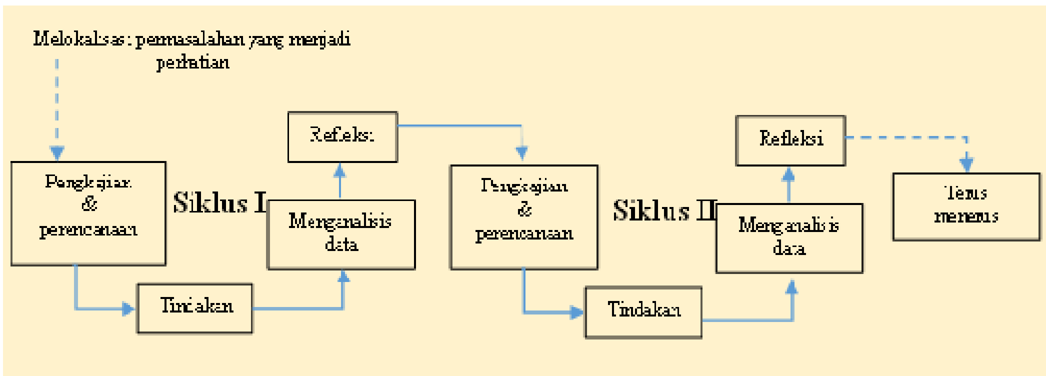


Figure 1. Margaret Riel's action model for the classroom.

Class XI MS 3 SMAN Plus Riau Province is the focus of the research. There are 29 pupils in total, 18 of whom are male and 11 of them are female. The study's independent variable was the Project Based Learning (PjBL) paradigm, whereas the dependent variable was students' growing science literacy. An assessment sheet for science literacy is the means of gathering data. Descriptive analysis was the method of data analysis employed. There were eight sessions total four in cycle I and four in cycle II during which the research was conducted. In order to improve the outcomes and meet the success metrics, this research was conducted sustainably throughout two cycles. Table 1 displays the stages involved in this investigation.

Table 1. Phases of research

Cycle 1			
Localize the problems that affect you	Science literacy test sheet for students	Distributing questions to students in class XI MS 3	The mean proportion of survey responses that meet the science literacy standards (Purwanto, 2009)
Planning	Verify educational resources	Give the validator team the validity sheet	Using descriptive statistical analysis (Likert scale analysis)
Action	Utilizing validated teaching resources, such as observation sheets	Documentation of learning activities	• Average percentage of learning activity questionnaire results • Averaging student science literacy test

Cycle 1	
	results (score values) • Guttman scale analysis (on questionnaire)
Data analysis	Utilizing descriptive analysis to analyze instruments provided during the action and observation process (averaging, translating quality numbers into numerical values, calculating percentages, etc.)
Reflection	Following data analysis, partner teachers and students engage in reflection
Cycle 2	
Planning	Validation of learning aids and data collection tools is also done in Cycle II, based on the findings of the reflection that was completed in Cycle I
Stage of action for data analysis	Similar to cycle I, if students demonstrate modifications in their learning process and align with the researcher's aims, then cycle II reflection indicates that the class action study is finished. If it isn't acceptable, though, it can carry over into the following cycle

At every meeting, science literacy is taught based on pre-existing competencies, specifically: 1) Scientifically explain phenomena; 2) Assess and plan scientific studies; and 3) Scientifically interpret data and evidence (OCED, 2018). Each cycle of testing requires researchers to create a grid with elements of both competency and content. Three topics will be examined: 1) Earth and space systems; 2) Living systems; and 3) Physical Systems (a concept in physics). A lattice of cycle I and cycle II science literacy questions is provided here.

Table 2. Grid for science literacy in cycle I

Competence	Konten	Question Number
Determining the Scientific Basis for Phenomena	Analyze information and proof using a scientific approach	5
	Planet Venus in transit *(earth and space systems)*	4
	Biodiversity *(living systems)*	6
Assess and plan scientific studies	Cloning technology *(living systems)*	7
	Properties of light *(physical systems)*	8
	Semmelweis Diary *(Living systems)*	9
Analyze information and proof using a scientific approach	Tooth decay *(living systems)*	1
	Golden plovers *(earth and space systems)*	2
	Ocean depths and sonar systems *(physical systems)*	3

Table 2 indicates which test questions satisfy the competency and content requirements for science literacy. Students have studied part of the curriculum long before the class action was put into practice. Additionally, two of the nine questions the characteristics of light and the transit of Venus have just been examined. (application of the telescope). The researcher completed the test at the conclusion of cycle I, took some time to think, and then completed a science literacy test at the end of the cycle. A lattice of cycle II science literacy problems is provided here.

Table 3 demonstrates that physics ideas are covered more than general knowledge. The reason for this is that high school kids are the ones being tested. Students need to be able to apply the principles they have studied about physics learning in addition to having science literacy abilities. Table 4 displays the success criteria for science literacy skills.

Table 3. Grid for science literacy in cycle II

Competence	Content	Question Number
Determining the Scientific Basis for Phenomena	Bosscha Observatory *(earth & space systems)*	1
	Adjustable glasses *(living systems)*	8
	Helmet as head protection *(physical systems)*	2
Assess and plan scientific studies	Parallel rays through a lens *(physical systems)*	3
	Greenhouse Effect *(living systems)*	4
	Volcanic eruption *(earth and space systems)*	5
Analyze information and proof using a scientific approach	Spring on baby swing *(physical systems)*	6
	Bread dough *(Living systems)*	7
	Pendulum on the equator *(Earth and physical systems)*	9

Table 4. Science Literacy Criteria

Value	Predicate
80-100	Very high
76-85	High
60-75	Medium
55-59	Low
54	Very low

Source: Purwanto (2009)

The average score for each student indicated in each cycle shows the development of the kids' science literacy. The Classroom Action Research can be finished if the students' test results in at least two cycles match the intended predicate. (Arikunto, 2019).

Results and Discussions

The purpose of this study was to determine whether project-based learning (PjBL) combined with STEM subjects could improve students' scientific literacy. Twelve meetings were held throughout two cycles of the research. Project-based learning (PjBL) in STEM has four steps: 1) Application, 2) Research, 3) Discovery, and 1) Reflection.

a. Cycle I

Cycle I was run at various times from Tuesday, March 8, 2023, to Wednesday, March 29, 2023. Researchers administered a pretest on Tuesday to ascertain the starting science literacy levels of the kids. The first and second hours (07.15 - 08.45 WIB) were used for the lesson. In the meantime, the researcher spent the remaining two hours of Wednesday's classes (14.30–16.00 WIB) teaching.

1. Learning implementation in Cycle I

Cycle I's implementation of learning begins with the content on light waves, which includes the following: 1) describing how light is reflected, refracted, and dispersed; 2) applying these principles; 3) Light Interference; 4) Light Diffraction; and 5) Light Polarization. Each material's technical implementation is,

The teacher used a diagnostic exam (meeting-1) with four science literacy-related questions to assess the pupils' starting proficiency. Following the students' responses, the instructor used PjBL-STEM procedures to carry out the lesson. Teachers verify for understanding and revisit material during the reflection stage. They also provide films or graphics to enhance learning, communicate learning objectives, and communicate learning summaries. Additionally, by employing worksheets and providing a classical explanation of the content, the instructor supports student learning and develops their science literacy abilities during the research stage. The worksheets that is utilized at every meeting is as follows.

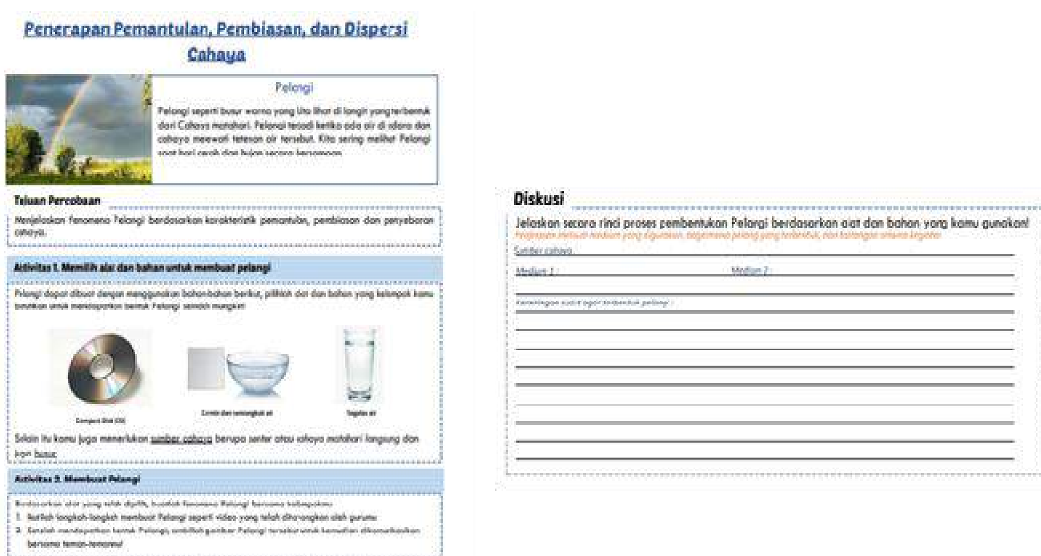


Figure 2. Worksheet at meeting-1.

According to the worksheets, it is evident that the instructor offers an intermezzo in the form of the rainbow process before giving students options for creating rainbows using different supplies and instruments. Additionally, the teacher develops students' science literacy in the area of scientific explanation of occurrences through the discussion feature. To help students with their replies, the teacher marks the page with blue and orange markers. The next stage after conducting an investigation is discovery. Students now rehearse the product that will be manufactured and explain how the notion is incorporated into the product by giving presentations in front of the class. Moreover, application is the final step. By now, the concepts in the products have been grasped by the students, so they are polished and brought to the teacher. Infographics featuring rainbows and light polarization will be created from certain products that are not able to be collected. These are a few items from Light Wave Learning.

The image illustrates that summarizing assignments is another way to help students improve their science literacy. Then, utilizing images or other captivating texts, this synopsis is produced.

(a) (b) (c)

Figure 3. (a) Rainbow phenomenon infographic, (b) Hologram, (c) Light polarization infographic.

The image illustrates that summarizing assignments is another way to help students improve their science literacy. Then, utilizing images or other captivating texts, this synopsis is produced.

2. Profile of Students' Science Literacy Skills in Cycle I

Following the PjBL-STEM model's implementation and the creation of a variety of products centered on the fundamental skill of light waves, students' literacy abilities were assessed using a science literacy test sheet that uses the grid shown in Table 2. Each ability in the test results is represented in the table that follows.

Table 5. Profile of Students' Science Literacy Skills in Cycle I

Competence	Average	Kategory
Determining the Scientific Basis for Phenomena	72	Medium
Assess and plan scientific studies	75	Medium
Analyze information and proof using a scientific approach	46	Very low

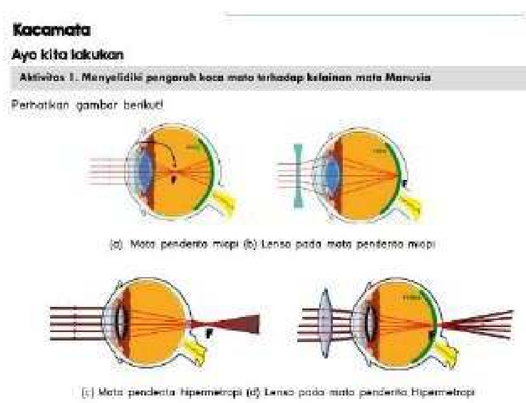
Among the skills required of a person who is scientifically literate is the evaluation and design of scientific research. The reason for the low ability is that pupils simply concentrate on computations without understanding the principles they are learning. This is consistent with research Priyadi (2018) it was discovered that pupils could only perform calculations in physics (inference) and could not evaluate or interpret the results. As they solve difficulties in the problem, students struggle to recognize false assumptions and data that is not provided.

b. Cycle II

Cycle II took place from Tuesday, May 03, 2023, to Wednesday, May 18, 2023. In line with cycle I, instruction took place in the first and second hours (07.15–08.45 WIB), and in the latter two hours of Wednesday (14.30–16.00 WIB), researchers conducted lessons.

1. Implementation of learning in Cycle II

The content covered in Cycle II is an extension of Cycle I, namely the section on Optical Instruments. The topics covered in this section include understanding concepts, doing experiments, and drawing diagrams of light. The content is broken down into five sessions: 1) Overview of optical devices; 2) Mirrors, both flat and curved; 3) Concave and Convex lenses; 4) Optomechanical devices for the eye and microscope; and 5) Optomechanical devices for telescopes and periscopes. As with cycle I, the teacher uses worksheets, virtual experiments, and product creation to help students learn and develop their psychomotor and literacy skills. In this cycle, the worksheets listed below were employed.



Berdasarkan ilustrasi tersebut, lengkapi Tabel 1. Pengaruh kacamata terhadap kelainan mata berikut

Tabel 1. Pengaruh kacamata terhadap kelainan mata

No	Kondisi mata	Miopi	Hipermetropi
1.	Pembentukan Bayangan		
2.	Setelah menggunakan Kacamata		
3.	Lensa yang digunakan		

(a) (b)

Figure 4. (a) illustration of eye defects, (b) identifying illustrations.

Figure 5. Products on basic competencies of optical devices (cycle II).

In cycle II, the instructor employed worksheet training as a way to help students become even more proficient at recognizing and understanding data. Students are provided images in Figure 4, and they can recognize the creation of shadows and other features from these illustrations. Similarly, in the worksheets of more sessions in this cycle II.

Cycle II of the worksheets developed both optical devices and presentation materials over an extended period of time. Students can show their creativity in learning through the use of presentation materials in the form of mading.

2. Profile of Students' Science Literacy Skills in Cycle II

Following the PjBL-STEM model's implementation and the creation of a variety of products based on Light Waves' Basic Competency, students' literacy abilities were assessed using a science literacy test sheet that made use of the grids shown in Table 3. Each competency shown in the following table represents the test results.

Table 5. Profile of students' science literacy skills in cycle II

Competence	Average	Category
Determining the Scientific Basis for Phenomena	79,3	High
Assess and plan scientific studies	77	High
Analyze information and proof using a scientific approach	60	Medium

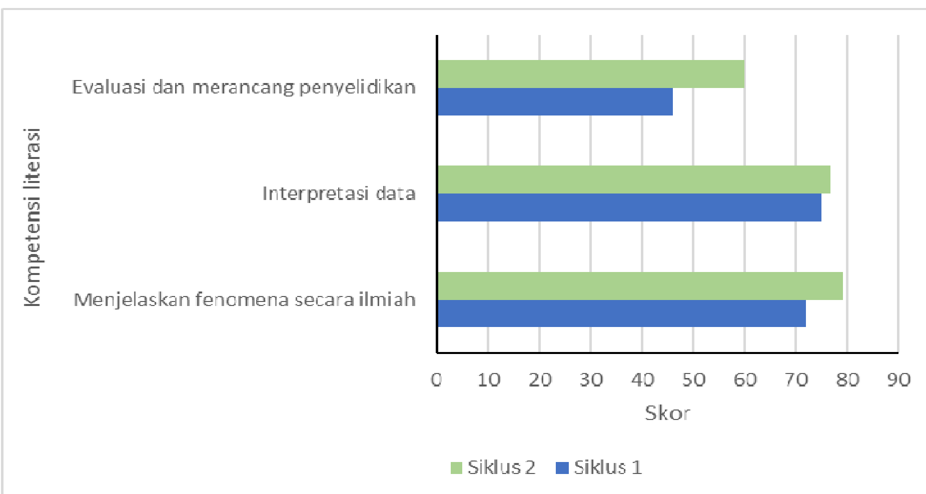


Figure 6. Comparison of students' science literacy skills.

There are some variations between cycles I and II. beginning with variations in both the methods of implementation and the outcomes of the literacy abilities of the students. The following graphic compares the science literacy outcomes for students in cycles I and II.

According to Figure 6, students' science literacy skills improved in cycles I and II, which is consistent with the study's findings (Afriana et al., 2016; Sakti & Swistoro, 2021). This rise can be attributed to a number of factors, including the use of suitable learning models, the provision of tasks that develop students' capacity for explaining phenomena, the use of discussion-based learning techniques, the facilitation of learning through worksheets, and the implementation of rewards and penalties.

According to the results of the classroom action research, the average science literacy competency increased from 64.3 in cycle I to 72.1 in cycle II with the use of the PjBL-STEM model. Therefore, it was determined that this study was successful in raising the science literacy levels of SMA Plus Pekanbaru students in class XI MS 3.

Conclusion

The PjBL paradigm coupled with STEM has improved students' science literacy. The teacher's actions include adopting the proper learning model, assigning tasks that develop students' explanation skills, utilizing discussion-based learning techniques, facilitating learning with LKPD, and assigning rewards and penalties. Students' average score went from 64.3 to 72.1. This study can be used as a reference by future researchers, who can also apply the PjBL-STEM model by adding more suitable variables.

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