



INTEGRATION OF PJBL-SETS IN MULTIMODAL TEACHING MATERIALS TO IMPROVE STUDENTS' SCIENCE LITERACY AND ENVIRONMENTAL AWARENESS

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ABSTRAK

Improving thinking skills in learning can be done through the application of learning methods that suit the needs of students. This study aims to examine the integration of the Project-Based Learning (PjBL) model with the Science, Environment, Technology, and Society (SETS) approach in multimodal teaching materials that can improve students' science literacy and environmental concern. Learning that is still theoretical and less contextual causes a low ability of students to relate science concepts to real life. In addition, this research aims to analyze the effectiveness of project-based learning that is integrated with science, environment, technology, and society approaches and supported by multimodal teaching materials in improving students' science literacy and environmental concern for vertebrate materials in mangrove ecosystems. The method used is a quasi-experiment with a pretest-posttest control group design. The research subjects consisted of 25 students of Biology Education FKIP UNSAM, 19 students of Biology Study Program of Science and Technology of UNSAM and 23 students of Tadris Study Program FITK UINSU. Data were collected through science literacy tests and environmental awareness questionnaires, then analyzed using improvement scores and percentages. The results of the study showed that students' science literacy increased significantly in the high category, while environmental awareness was in the sufficient category. These findings show that project-based learning combined with contextual approaches and multimodal teaching materials is effective in improving students' cognitive abilities and attitudes. The implications of this study emphasize the importance of implementing innovative learning strategies to create meaningful learning that is relevant to environmental issues.

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1. INTRODUCTION

The development of high-level thinking skills, science literacy, and character formation that cares about the environment are one of the learning transformations in the 21st century that does not only focus on concepts. In the global context, environmental issues such as climate change, ecosystem degradation, and pollution are serious challenges that require the active role of the young generation as agents of change (Luthfia, 2025). Therefore, education has a strategic role

in shaping individuals who not only understand scientific concepts, but also have awareness and concern for the environment. However, various studies show that students' environmental concern is still relatively low. This is shown by the lack of active involvement of students in protecting the environment and the low ability to relate science concepts to real problems around them (Ridho et al., 2021). This condition is inseparable from learning practices that still tend to be theoretical and less contextual. Teacher-centered learning causes students to become passive and lack meaningful learning experiences. In addition, students' science literacy is also an important concern (Cairns, 2025). Science literacy includes not only understanding concepts, but also the ability to interpret data, evaluate information, and make decisions based on scientific evidence.

Low science literacy has an impact on students' low ability to understand environmental issues critically. This is in line with the findings that there is a close relationship between science literacy and environmental concern, where individuals with good science literacy tend to have higher attitudes of caring for the environment (Faize & Akhtar, 2020). In the context of science learning, an approach that is able to integrate knowledge with real-life contexts is needed. One relevant approach is Project-Based Learning (PjBL). This model emphasizes the active involvement of students in solving real problems through structured project activities.

Project-Based Learning (PjBL) has been widely researched as an effective learning model in improving various competencies in the 21st century. PjBL allows students to learn through hands-on experience, so that learning becomes more meaningful. The results of the study show that PjBL is able to improve science literacy, critical thinking skills, and environmental concern for students. The application of PjBL in environmental learning has been proven to be able to increase environmental awareness through student involvement in real projects related to environmental problems (Herman et al., 2020). Other research also shows that PjBL has a positive influence on environmental care, because students are directly involved in activities that demand responsibility for the environment (Safitri et al., 2021). The integration of PjBL with the concept of sustainability or Sustainable Development Goals (SDGs) has also been proven to be able to increase students' awareness of sustainability. This shows that project-based learning has great potential in shaping the character of caring for the environment (Rahmawati et al., 2020).

However, although PjBL has proven to be effective, its implementation still faces various challenges, such as the limitation of teaching materials that support project-based learning and the lack of integration with contextual approaches. Therefore, innovation is needed in the development of teaching materials that are able to support the implementation of PjBL optimally. One of the approaches that can be integrated with PjBL is the Science, Environment, Technology, and Society (SETS) approach (Rustana et al., 2021). The SETS approach emphasizes the interconnectedness between science concepts and the environment, technology, and society, so that learning becomes more contextual. This approach allows students to understand that the concept of science does not stand alone, but has real implications in everyday life (Chandra et al., 2020).

In addition to learning models and approaches, teaching materials also have an important role in determining the success of learning. Innovative teaching materials can increase student engagement and facilitate a deeper understanding of concepts (Tran & Nagirikandalage, 2025). One of the innovations in the development of teaching materials is the use of multimodal teaching materials, which are teaching materials that integrate various forms of representation such as text, images, audio, video, and digital interaction (Zenouzagh et al., 2023). Recent research shows that PjBL-based teaching materials in the form of e-modules are able to significantly increase students'

environmental awareness and problem-solving skills. Environmental awareness increases after the use of e-modules and PjBL helps students understand local environmental issues (Handayani et al., 2021). This shows that the integration of learning models and innovative learning media can have a positive impact on learning outcomes (Prasanti et al., 2023).

Although various studies have shown the effectiveness of PjBL in improving science literacy and environmental awareness, there are still some research gaps. First, most research still focuses on one aspect, namely science literacy or environmental concern, without integrating the two comprehensively. Second, research that integrates PjBL with the SETS approach is still limited, especially in the context of higher education. In fact, this integration has great potential in creating contextual and meaningful learning. Third, the use of multimodal teaching materials in project-based learning has not been widely studied, especially in the context of science learning in specific materials such as mangrove and vertebrate ecosystems. Fourth, most of the previous research was conducted at the primary and secondary education levels, so research at the higher education level is still very limited.

The novelty of this research lies in several aspects, namely the integration of three main components in the form of PjBL, the SETS approach and multimodal teaching materials that focus on student environmental awareness, the context of mangrove ecosystem-based learning, and a multidimensional approach. The contribution of this research for the future of the three aspects of integration is to maintain the mangrove ecological ecosystem. Mangroves as a means that can be used as a literacy environment with all ecosystems in it.

2. METHOD

This study uses a quasi-experimental method with a Pretest-Posttest Control Group Design (Creswell & Creswell, 2023), with a sample of 25 people in the Biology Education Study Program, FKIP Samudra University, 19 people from the Biology Study Program, Faculty of Science and Technology, Samudra University, and 23 people from the Tadris Study Program, FITK UINSU. The effectiveness of teaching materials is measured from science literacy and environmental awareness test data through science literacy tests in the form of selected objective test questions in the form of pretest and post scores. Pretest and post-test questions consist of 20 questions that have been tested for students of the Biology Study Program FITK UINSU and are suitable for use. Furthermore, it is analyzed using standard n-gain to see whether there is an increase in science literacy and student concern in students of the Biology Education Study Program FKIP and the Biology Study Program, Faculty of Science, Samudra University. Research from (Riduwan, 2016) which uses a quasi-experimental method with a Pretest-Posttest Control Group Design. The effectiveness of teaching materials is measured from science literacy and environmental awareness test data. The science literacy test is in the form of optional objective test questions in the form of pretest and post-test scores and is then analyzed using standard gains to see whether there is an increase in science literacy and concern for students of the Biology Education Study Program FKIP and the Biology Study Program, Faculty of Saintek, Samudra University and the FITK Biology School of the State Islamic University of North Sumatra.

$$< g > = N \text{ gain} = \frac{(post - test \text{ score}) - (pre - test \text{ score})}{(maximum \text{ score}) - (pre - test \text{ score})}$$

The criteria for the N-gain value obtained are interpreted as follows:

Table 1. Interpretation of Gain Value Acquisition (Hake, 2009)

Average	Criteria
$g \geq 0,70$	Height
$0,3 \leq g < 0,70$	Medium
$g < 0,30$	Low

The effectiveness of the teaching materials can be seen from the success of lecturers using teaching materials complete with the PjBL model in teaching about vertebrate zoology for students and the results of the student environmental concern questionnaire. The calculation of the Student Environmental Concern questionnaire will be grouped according to the percentage of respondents' answers and become a benchmark in making conclusions, so to get the percentage is adjusted to the criteria according to the criteria according to (Sudijono, 2012):

$$P = \frac{F}{N} \times 100\%$$

The variables are defined as follows, P is the percentage of alternative answers, F refers to the frequency of respondents' alternative answers, and N represents the sample size of the research. To find out the criteria for an attitude of environmental concern was presented in Table 2:

Table 2. Criteria for the Percentage of Environmental Concern Attitude Questionnaire

Score (%)	Category
0-20	No matter
21-40	Quite care
41-60	Quite care
61-80	Care
81-100	Very caring

(Riduwan, 2016)

3. RESULTS AND DISCUSSION

3.1. Scientific Literacy

The effectiveness of the vertebrate PjBL model in mangrove forests using a multimodal teaching material was carried out a science literacy test for students (Biology Study Program FITK UINSU, Biology Study Program FT UNSAM and Biology Education Study Program FKIP UNSAM) as many as 20 questions. In addition to the science literacy test, the test was also carried out using environmental awareness questionnaires as a social form of students towards the surrounding environment, namely mangrove forests which are rich in benefits both economically and in natural sciences, which are related to the lives of all living beings.

The results of the science literacy scores of students who have been tested on students (Biology Study Program FITK UINSU, Biology Study Program FT UNSAM and Biology

Education Study Program FKIP UNSAM) are 20 questions, the results were presented in Table 3:

Table 3. Student Science Literacy Score Data

No.	Study Programs	Average Science Literacy Score		N-Gain	Criteria
		Pretest	Post-Test		
1	Department of Biology Education FITK UINSU	35	81	0,71	High
2	Department of Biology Education FKIP UNSAM	35	82	0,72	High
3	Biology Study Program FT UNSAM	34	83	0,78	High

Judging from the average science literacy score of the Biology Study Program of FITK UINSU, the pre-test score of 35 and the post-test score of 81 with an N-Gain value of 0.71 including high criteria gives a very positive picture of the improvement of student science literacy. A pre-test score of 35 indicates the level of science literacy of students before learning. The pre-test score of 35 shows that before learning, students have a fairly low understanding of vertebrate animal material in mangrove forests related to science literacy associated with the concept of SETS. After learning was carried out using the PjBL model and multimodal teaching materials with the SETS approach, a post-test score of 81 showed that there was a very significant increase in understanding and mastery of the material by students who had succeeded in mastering the material better after following the learning process that had been designed. The post-test score was much higher than the pre-test score showed that the learning carried out succeeded in improving students' understanding of vertebrate material in mangrove forests. This significant improvement reflects that the material delivered, the learning methods used, and the interactions that occur during learning are effective in improving students' science literacy.

An N-Gain value of 0.71 is within the high criterion, which means that there is a significant improvement in students' science literacy after learning. With this score, it can be concluded that the learning strategy applied using the vertebrate PjBL model in mangrove forests with the SETS approach using multimodal teaching materials has succeeded well in improving students' science literacy. This high N-gain value reflects excellent learning quality. The methods applied in the learning process successfully facilitate students to master the material better than before, which can include improving the understanding of scientific concepts, critical thinking skills, and the application of knowledge in real-life contexts.

The results of the average science literacy score of the Biology Education Study Program FKIP UNSAM, the pre-test score of 35 and the post-test score of 82 with an N-Gain value of 0.72 including high criteria provide a positive picture of the improvement of student science literacy. A pre-test score of 35 indicates the level of science literacy of students before participating in learning. A pre-test score of 35 shows that students have a relatively low understanding of concepts related to animal vertebrate science literacy in mangrove forests before learning begins. After learning, a post-test score of 82 shows a very significant increase in students' understanding of the material that has been taught. This value indicates that after following the learning process,

students have mastered the material better. The pre-test score of 35 and the post-test score of 82 show that there has been great progress in mastery of the material by students.

The above results indicate that the learning carried out is very effective in improving students' science literacy. With a significant improvement, this reflects the good quality of teaching. Students successfully overcome initial difficulties in understanding vertebrate material in mangrove forests and showed substantial progress after learning. The N-Gain value of 0.72 was in the high criterion, which indicates a significant improvement in the overall material understanding of vertebrates in mangrove forests by students. This means that the applied learning has succeeded in increasing student knowledge in terms of science literacy, with a considerable increase between pre-test and post-test scores.

The results of the average science literacy score of the FT UNSAM Biology Study Program, the pre-test score of 34 and the post-test score of 83 with an N-Gain value of 0.78 including the high criterion provide a very positive indication of the improvement of student science literacy. The pre-test score of 34 shows that students have a fairly low understanding of vertebrates in mangrove forests before learning begins. The pre-test score of 34 gives an idea that many students may not have adequate basic knowledge about the science topics to be taught.

After participating in the learning, the post-test score of 83 showed a significant improvement. This indicates that students have mastered the material very well after the learning process, which illustrates the effectiveness of the teaching strategies applied. The huge difference between the pre-test (34) and post-test (83) scores shows that students have made significant progress in their understanding of the material. This signifies that learning has successfully overcome students' initial knowledge gaps. These excellent results reflect the high quality of teaching and effectiveness.

Students not only improve their knowledge but also gain a better and deeper understanding of the topics being taught. The increase in high science literacy also reflects that students are not only mastering information theoretically, but also beginning to apply their knowledge in practical contexts, such as experiments or science problem-solving. The value of N-gain = 0.78, which falls under the high criterion, can be concluded that there is a significant increase in students' science literacy. This value shows that the learning carried out has succeeded in improving student understanding substantially, with an excellent improvement from pre-test to post-test. For more details, see Figure 1.

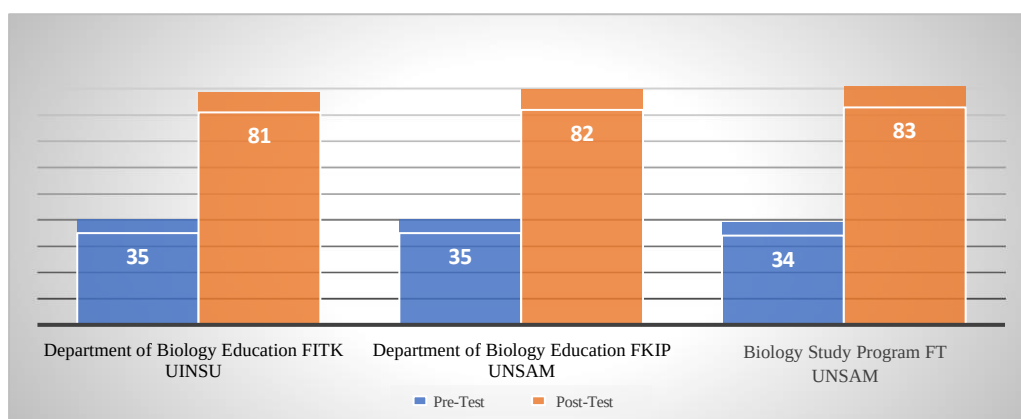


Figure 1. Histogram of Student Pre-Test and Post-Test Science Literacy Scores

3.2. Student Environmental Concern

The effectiveness of the PjBL Vertebrate learning model in mangrove forests using the SETS approach using multimodal teaching materials was also obtained from the results of pilot research on the dissemination of environmental awareness questionnaires for students (Biology Study Program FITK UINSU, Biology Study Program FT UNSAM and Biology Education Study Program FKIP UNSAM). The following results of the student environmental concern questionnaire are explained in Table 4.

Table 4. Student Environmental Awareness Questionnaire Value Data

No.	Institutions	Total Average	Average Percentage	Criteria
1	Department of Biology Education FITK UINSU	35,87	59,78	Simply Care
2	Department of Biology Education FKIP UNSAM	34,92	58,2	Simply Care
3	Biology Study Program FT UNSAM	36,68	61,14	Care
Average		35,82	59,71	Simply Care

Based on Table 4, the data table of environmental concern questionnaire scores tested to students (Department of Biology Education FITK UINSU, Department of Biology Education FKIP UNSAM and Biology Study Program FT UNSAM) it can be seen that students in the three Study Programs have an average score of 35.82 and an average percentage of 59.71% including the criteria of being quite caring, this shows that students show a moderate level of attention to environmental issues. Despite the concern for environmental conservation, this figure indicates that there is still room to increase student awareness and involvement in environmental activities. In other words, even though students care enough, more intensive efforts are still needed to improve their understanding and real action related to environmental issues, such as through more in-depth education or more interactive and applicable programs.

3.3. Discussion

Learning with the help of multimodal teaching materials can significantly increase student literacy because of the effectiveness of multimodal compared to only conventional (Arifin et al., 2025). This approach can facilitate a better understanding, especially in the biological sciences which often involve experimentation and application of scientific concepts. The use of multimodal teaching materials with a SETS component complete with independent learning based on the PjBL model with a SETS approach is also the initial determination of the achievement of increasing the value of student science literacy. This multimodal teaching material is equipped with photos and even interactive video links so that students understand more about each material presented. The use of text equipped with animations in multimodal teaching materials in science education makes a strong understanding of scientific concepts (Montenegro et al., 2020).

The multimodal teaching materials are also equipped with links to SETS components related to activities in mangrove forests so that there is feedback related to social, environmental, animal utilization technology and results in mangrove forests and inseparable from science related to vertebrates in mangrove forests. Improving students' skills in the context of utilizing relevant information, finding and evaluating obtained with the right technology so as to encourage the development of science literacy as well as critical thinking skills and evidence-based conclusion making (Putri et al., 2025).

The effectiveness of the PjBL Vertebrate Learning model in Mangrove Forests with a SETS Approach Using Multimodal Teaching Materials can also be seen by obtaining an average student concern questionnaire score of 35.82 and a percentage of 59.71% for the three study programs studied. This shows that students are able to care about the mangrove forest environment. Multimodal teaching materials that have completeness in the form of texts, images and videos related to mangroves and vertebrates support visual understanding and real context (Sucilestari et al., 2025). Learning with the SETS approach introduces the technology used to monitor and maintain the sustainability of mangrove ecosystems. This learning makes students understand the mangrove ecosystem visually, digitally and interactively and are able to apply aspects of science, environment, technology and social society (Noga et al., 2022).

Teaching materials that connect science, the environment, and society, students can see how mangrove conservation efforts not only impact the environment but also the surrounding community (Pouloupoulou, 2025). This broadens their insights into the relationship between ecosystems and human well-being. Multimodal teaching materials are also equipped with videos that are covered with links and barcodes that connect directly to the video according to the material being studied. This supports more flexible and depersonalize learning. This is the starting point because multimodal teaching materials equipped with texts, images and videos are the main supporters in the independent learning process at the University level (Nouri, 2019).

The multimodal teaching materials produced do not only function as learning support media. The representations available in the teaching materials are associated with the context of SETS which is the basis of learning problems. Photos and videos about mangroves are a tool for students who can connect vertebrate characteristics with habitats and environmental conditions (Desy et al., 2026). The SETS component contained in the teaching materials determines the context and relevance of the information, while multimodality provides a way to represent and understand the information (Hüfner et al., 2026). This relationship is what makes multimodal teaching materials part of the learning mechanism, not just a technological feature.

The application of learning methods is basically all good, but learning characteristics need to be identified so that the model applied is according to learning needs (Franco et al., 2021). The need to learn with the use of the right methods will become more relevant to improve students' abilities (Solehuudin & Budiman, 2019). The need to learn with the use of the right methods will become more relevant to improve students' abilities (Novita & Mukhtar, 2024). Mangroves are used as a means of learning that can improve students' science literacy, in line with this opinion of research from (Basyuni et al., 2022), stating that mangroves in Sumatra and Aceh have a rich diversity of vertebrate biodiversity so that they can be a source of learning and research centers. However, maintaining the environment so that mangroves remain a sustainable ecosystem is very necessary.

The application of knowledge through PjBL is obtained by students through the SETS component and information from various multimodal representations, project activities provide opportunities to use this knowledge (Mackay & Davenport, 2019). Students can investigate, discuss, collect information, evaluate evidence, work together, and produce solutions to the problems studied. The function of PjBL in this mechanism is to turn understanding into activities and applications. This is in line with the characteristics of PjBL which places students in problem-solving activities and authentic learning experiences. The interaction of the three components is in detail, namely SETS answers why science concepts are important to learn, multimodal teaching materials help students understand how these concepts and problems are represented, while PjBL provides opportunities to apply this knowledge through actions and project completion. With this pattern, learning moves from context to meaning and then to application (Jeppsson et al., 2026).

The application of these three aspects of learning is a method that can be recommended for student learning so that learning abilities and characteristics increase. Learning using mangrove facilities can increase students' science literacy which can encourage more meaningful learning skills through direct experience in nature.

4. CONCLUSION

Based on the results of the research and discussion, it can be concluded that the integration of the Project-Based Learning (PjBL) model with the SETS approach in multimodal teaching materials is effective in improving science literacy and environmental concern for students. In the aspect of science literacy, there was a very significant increase in all study programs studied. The relatively low pre-test average score (34–35) increased drastically in the post-test (81–83), with N-Gain values ranging from 0.71–0.78 which was in the high category. The aspect of environmental concern shows that students have a level of concern in the category of caring enough with an average percentage of 59.71%. This indicates that PjBL-SET-based learning with multimodal teaching materials has been able to foster student awareness of the importance of environmental conservation, especially mangrove ecosystems. However, this level of concern still needs to be improved through learning activities that are more applicable, sustainable, and based on real actions in the field. Overall, the integration between the PjBL model, the SETS approach, and multimodal teaching materials (text, images, videos, and digital interactions) is able to create learning that is contextual and meaningful, interactive and engaging, and relevant to students' real lives. This learning not only improves cognitive competence (science literacy), but also begins to shape students' attitudes and environmental awareness (affective). Thus, it can be concluded that the learning model developed is suitable for use as an alternative to learning innovation in higher education, especially in improving students' science literacy and environmental awareness, although further strengthening is still needed to improve the aspect of environmental concern into a higher category.

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