Strengthening Science Literacy and Spiritual Values Through Bio-Integrated Learning at Kanzul Mubaarok Boarding School Bekasi

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Abstract
Purpose of this study is to develop and analyze a science learning model that enhances scientific literacy while simultaneously strengthening students' spiritual values. The background of this research is the low level of scientific literacy among Indonesian students and the lack of integration between science learning and religious values. Boarding schools are considered potential environments to implement innovative learning that connects biotechnology concepts with the teachings of the Qur'an through Bio-Integrated Learning based on project work. Methodology of this study applied a descriptive quantitative approach with a classroom action research design involving grade Ten students at Boarding School Kanzul Mubaarok Bekasi in the biology subject. The procedure included planning learning instruments, implementing biotechnology projects linked to spiritual reflection, and evaluating outcomes through pre-test and post-test of scientific literacy, questionnaires on spiritual values, and classroom observations. Findings of the research reveal improvements in scientific literacy, understanding of biotechnology concepts, critical thinking skills, student collaboration, and spiritual awareness reflected in their attitudes and reflections. Originality of this study lies in the integration of biotechnology learning with spiritual values through Bio-Integrated Learning based on project work, contributing to the development of contextual learning strategies that support the Merdeka Belajar curriculum.

Keywords: Bio-Integrated Learning, Scientific Literacy, Project Based Learning

1. Introduction

Science literacy is one of the key competencies that students must possess in order to face the global challenges of the 21st century. This competency not only includes understanding scientific concepts, but also the ability to analyse problems, make decisions based on evidence, and apply scientific knowledge in everyday life. According to Arohman et al. (2016), scientific literacy is the ability to use scientific knowledge, identify questions, and draw conclusions based on facts and data to understand the universe and make decisions about changes caused by human activities. Meanwhile, according to Yusmar and Fadilah (2023), scientific literacy covers three main aspects: scientific knowledge, scientific processes, and application in real contexts. A good understanding of science enables students to make evidence-based decisions and contribute to solving global problems such as climate change, health, and technology. However, data released by the Programme for International Student Assessment (PISA) shows that Indonesian students' scientific literacy skills are still below those of other countries. This indicates a gap in the national education system, particularly in the application of relevant and contextual learning methods to improve students' scientific literacy competencies (Yusmar & Fadilah, 2023).

Science education in many schools tends to focus on cognitive aspects without providing space for the development of spiritual values. In fact, spiritual values are an important element in shaping students' characters so that they not only excel in science but also have strong faith. Mujiburrahman (2018) said that Islamic science education is one of the systematic and effective media for building and strengthening the character of the nation. Kanzul Mubaarok Boarding School in Bekasi, as a religious-based school, has a great opportunity to integrate science learning with spiritual values based on the Qur'an and Hadith. However, like many other religious-based schools, science learning in this school is still not fully integrated with the religious context that can strengthen students' character.

Innovative approaches such as Bio-Integrated Learning offer solutions to address this gap. This approach enables the integration of modern scientific concepts, particularly biotechnology, with relevant spiritual values. For example, in learning about biotechnology, students can study concepts of fermentation, genetic engineering, and other bioprocesses while relating them to the values of the Qur'an, which emphasise the importance of utilising science for the welfare of humanity. This approach provides a learning experience that is not only contextual but also meaningful, where students understand science within the framework of religious values (Maulidah & Anwar, 2022).

One effective learning model that supports this approach is Project-Based Learning (PjBL). This model provides opportunities for students to engage in problem-based projects that are relevant to everyday life. Previous studies have shown that PjBL can improve students' critical thinking skills, creativity, and motivation to learn (Sari & Angreni, 2018). According to Hikmah et al. (2023), PjBL has several key characteristics: it is based on real problems, encourages collaboration, is results- or product-oriented, and places students at the centre of learning. Meanwhile, according to Arifianti (2020), Project-Based Learning is an innovative learning model that emphasises contextual learning through complex activities. Widodo et al. (2024) In the era of student-centred learning, the existence of such a curriculum is important and meaningful, especially when combined with project-based learning. However, the implementation of PjBL integrated with spiritual values is still very rare, especially in religious schools. This presents an opportunity for further research to develop a learning model that can integrate PjBL with the Bio-Integrated Learning approach.

Theoretically, science learning integrated with spiritual values has many benefits, both in terms of improving cognitive understanding and shaping students' character. However, empirically, the application of this learning model is still limited. A study by (Rahmawati et al., 2020) revealed that teachers in religious schools often find it difficult to integrate spiritual values into science learning due to limited guidelines and learning tools. Therefore, this study aims to develop a learning model that can integrate science and spiritual values holistically. The Kanzul Mubaarok Boarding School in Bekasi is an ideal place to implement this model because of its religious-based educational environment that supports the strengthening of students' spiritual values. Through this study, a PjBL-based Bio-Integrated Learning approach will be developed and

implemented to improve science literacy and strengthen students' spiritual values. By utilising relevant biotechnology concepts, students will be invited to understand science in the context of the values of the Qur'an and Hadith. The results of this study are expected to not only contribute to the development of learning theory but also serve as a practical guide for other religious-based schools to integrate spiritual values into science learning.

This study focuses on biotechnology material, one of the chapters in the Grade 10 Biology subject, namely creating a VCO innovation project. This study focuses on two main questions

1. How does the application of the Bio-Integrated Learning model based on Project-Based Learning (PjBL) improve students' science literacy in religious schools?
2. To what extent is the Bio-Integrated Learning model based on PjBL effective in integrating spiritual values into science learning?

This study aims to analyse the application of the Bio-Integrated Learning model based on Project-Based Learning (PjBL) in improving students' science literacy in religious schools, as well as to evaluate the effectiveness of this model in integrating spiritual values into science learning.

This research is expected to provide both theoretical and practical benefits. Theoretically, it adds insight into the development of learning theories that integrate science and spiritual values, as well as contributes to the study of science literacy within the context of religion-based education. Practically, the research offers several advantages: for students, it enhances science literacy while strengthening spiritual character through contextual and meaningful learning; for teachers, it provides references and practical guidelines for implementing the PjBL-based Bio-Integrated Learning model in the classroom; for schools, it offers an innovative learning model to improve the quality of science education in religion-based institutions; and for future researchers, it serves as a foundation for further studies aimed at developing and refining learning methods that integrate scientific understanding with spiritual values.

2. Research Method

This study uses a *pendekatan penelitian tindakan kelas (PTK)* approach to develop and evaluate a Bio-Integrated Learning model based on Project-Based Learning (PjBL) in improving science literacy and integrating spiritual values in religious schools. This research was conducted in stages over several cycles to obtain an effective learning model that suits the needs of students and teachers in science learning based on spiritual values.

Type of Research

The type of research used is *pendekatan penelitian tindakan kelas (PTK*)which is a research method that aims to improve learning practices directly in the classroom. *PTK* allows for interventions that can be evaluated and improved in each research cycle. With this method, Bio-Integrated Learning and PjBL-based teaching will be applied directly in the classroom, then analyzed for effectiveness through observation, interviews, and formative tests. This research was

conducted in several cycles to ensure that the developed learning model was truly capable of improving science literacy while strengthening students' spiritual values.

Research Subjects and Location

This research was conducted at Kanzul Mubaarok Boarding School in Bekasi, West Java, which is a religious-based school with great potential for integrating science learning with spiritual values. The research subjects consisted of 39 high school students who took biotechnology-based science courses in VCO production, as well as science teachers who acted as learning facilitators. This location was chosen based on the school's characteristics of being oriented towards Islamic values-based education, making it an ideal place to apply the PjBL-based Bio-Integrated Learning model.

Table 1. Characteristics of Research Subjects

Characteristics	N	Percentage (%)
Male	24	61.54
Female	15	38.46
Number of children	39	100

Source: Research data (2025)

This study adapts the Kemmis and McTaggart model of classroom action research, which consists of four main stages in each research cycle. The first stage, planning, includes several activities: preparing Bio-Integrated Learning and PjBL-based learning tools, such as teaching materials, learning media, and biotechnology-based project designs; developing learning scenarios that connect scientific concepts with spiritual values in alignment with the school curriculum; and preparing research instruments, including observation sheets, interview guidelines, and pre- and post-tests of scientific literacy to measure the effectiveness of the learning process.

Research Design

This study adapts the Kemmis and McTaggart model of classroom action research, which consists of four main stages in each research cycle. The first stage, planning, involves several key activities: preparing Bio-Integrated Learning and PjBL-based learning tools, including teaching materials, learning media, and biotechnology-based project designs; developing learning scenarios that integrate scientific concepts with spiritual values in accordance with the school curriculum; and preparing research instruments such as observation sheets, interview guidelines, and pre- and post-tests of scientific literacy to measure the effectiveness of the learning process.

Implementation (Action)

In this stage, students were first given a preliminary test to measure their initial level of scientific literacy. The teacher then implemented the PjBL-based Bio-Integrated Learning model

in the experimental class, where students engaged in biotechnology-based projects that were integrated with Islamic values. Students worked collaboratively in groups to complete the assigned projects, such as fermentation experiments, microorganism analyses, or studies related to the concept of halal in biotechnology. Throughout the learning process, the teacher provided continuous guidance and facilitated reflection to support students' understanding and project development.

Observation and Reflection

In the observation stage, the researcher observed students' engagement during the learning process, including their interactions while completing the projects and their understanding of the scientific concepts being studied. Data were recorded using observation sheets to evaluate the effectiveness of the learning model applied. In addition, both student and teacher responses to the implementation of the learning model that integrates science and spiritual values were analyzed to obtain a comprehensive picture of the action conducted.

In the reflection stage, a post-test was administered to measure improvements in students' scientific literacy after the intervention. Learning outcomes were analyzed to assess the effectiveness of the PjBL-based Bio-Integrated Learning approach. Challenges encountered during the learning process were identified, and solutions were formulated for improvement in the next cycle. The findings from the first cycle were then used as the basis for revising learning tools and teaching strategies before proceeding to the subsequent cycle.

3. Results and Discussions

This study presents a comprehensive overview of the learning process and outcomes in Biology about Biotechnology in making VCO, through the application of Bio-Integrated Learning based on Project-Based Learning (PjBL). The analysis focuses on two main aspects, namely the improvement of science literacy and the strengthening of spiritual values among 10th grade students at Kanzul Mubaarok Boarding School in Bekasi City. In general, the data shows a significant transformation, with students who initially lacked understanding of biotechnology concepts beginning to show improved understanding after engaging in project-based learning. In addition, the integrative learning design also provides space for the growth of spiritual values, such as gratitude, responsibility, honesty, solidarity, and environmental awareness.

Pre-test Results

A pre-test was conducted before learning to measure students' initial science literacy skills. The analysis results showed that most students did not yet understand the basic concepts of biotechnology and its applications.

Table 2. Science Literacy Pre-Test Results

Characteristics	N	Percentage (%)
Understanding Science	18	46,2
Do not yet understand science	21	53,8
Understanding Concepts	14	36,0
Do not yet understand concepts	25	64,0

Source: Research data pre-test (2025)

The data above shows that more than half of students have not mastered science literacy, both in terms of scientific understanding and conceptual understanding. This condition confirms that students need an innovative learning approach that is able to connect theory with practice.

Post-test Results

After learning with PjBL-based Bio-Integrated Learning, students were given a post-test to measure their improvement in science literacy and internalization of spiritual values.

Table 3. Science Literacy Post-Test Results and Integration of Spiritual Values

Characteristics	Average Score	Category
Improvement of science literacy	3,7- 3,8	Agree
Integration of spiritual values	4,3 – 4,5	Strongly agree

Source: Research data post-test (2025)

These results show that the average student score falls within the “agree” to “strongly agree” category. This means that students consider the learning model effective in improving their understanding of biotechnology while also fostering spiritual attitudes. The findings of this study show a significant increase in students' science literacy. Biotechnology projects carried out in groups encourage students to be more active in exploring concepts, engaging in discussions, and relating knowledge to real-life phenomena. In addition to cognitive aspects, this study also shows a consistent strengthening of spiritual values. The high average scores on the spiritual value integration indicator (4.3–4.5) show that students were accustomed to expressing gratitude, responsibility, honesty, and environmental awareness during the project. Contextual and reflective learning made it easier for students to internalize religious values

This study makes a new contribution by integrating science and spirituality in the context of boarding schools. Previously, students' science literacy was relatively low (pre-test), but after implementing the PjBL model based on Bio-Integrated Learning, there was a surge in understanding as well as the habit of religious attitudes. This emphasizes the importance of character education in every learning process, not just as additional content. Thus, the results of this study confirm that the application of Bio-Integrated Learning based on PjBL is not only effective in improving cognitive aspects but also has a significant impact on strengthening students' spiritual values. This model can be used as an alternative learning strategy in Islamic boarding

schools because it is able to address the challenge of low science literacy without neglecting the main mission of character and spiritual education.

4. Conclusions

The implementation of Bio-Integrated Learning based on Project-Based Learning (PjBL) in Biotechnology material in grade X at Kanzul Mubaarok Boarding School has been proven to significantly improve students' science literacy. Additionally, this learning method reinforces spiritual values such as gratitude, responsibility, honesty, and environmental awareness. The contextual and reflective project-based learning model allows students to internalize these values while mastering biotechnology concepts. Thus, this approach can be used as an effective learning strategy in Islamic boarding schools.

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