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THE EFFECT OF DIFFERENTIATED LEARNING MODEL BASED ON BIOTECHNOLOGY MATERIAL PROJECTS ON SCIENCE LITERACY REVIEW FROM THE LEARNING STYLE OF STUDENTS OF SMAN 1 TURI

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Abstract. This study aims to examine the effect of a project-based differentiated learning model on the scientific literacy of tenth-grade students in biotechnology material at SMAN 1 Turi, considering students' learning styles. The research method employed was a quasi-experimental design with a non-equivalent control group. The study involved two groups of students: the experimental group, which used the project-based differentiated learning model, and the control group, which used the discovery learning model. The results showed that the average Post-test score of the experimental group increased by 43.2%, from an average Pre-test score of 26.44 to 37.88. In contrast, the control group experienced only a 17% increase, from an average score of 29.91 to 31.41. Additionally, analysis based on learning styles revealed that students with visual learning styles experienced the highest increase in scientific literacy, followed by those with auditory and kinesthetic learning styles. Overall, the application of the project-based differentiated learning model increased learning effectiveness by 76% in the experimental group compared to conventional learning methods. This study concludes that a differentiated, project-based learning model is effective in enhancing students' scientific literacy, particularly in the field of biotechnology. It highlights the importance of considering learning styles in the learning process. These findings offer practical implications for teachers in designing innovative learning experiences tailored to students' individual needs.

Keywords: Differentiated Learning, Learning Styles, Scientific Literacy, Project-based Learning

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INTRODUCTION

The quality of a nation's education is an important measure of its progress and competitiveness globally (Manurung & Anazifa, 2024). In Indonesia, there has been continuous improvement in the education sector, as reflected in the evolution of the curriculum since independence to the present. Learning in the 21st century is characterised by a Student-Centred Learning (SCL) approach that develops four core skills: communication, collaboration, critical thinking and problem-solving, as well as scientific literacy and innovation (Pertiwi et al., 2023). Scientific literacy is an individual's ability to comprehend, apply, and critically evaluate scientific information in everyday life (Mukhlish & Paidi, 2025).

In the 21st century, characterised by uncertainty and disruption, scientific literacy has become a vital skill. This ability enables individuals to think critically, analyse information, and make decisions based on scientific data (Rath, 2022) . The importance of scientific literacy is reflected in the Independent Curriculum, which emphasises the development of this competency as a key aspect of education. Research by Pertiwi (2023) indicates that 21st-century science learning, combined with scientific literacy, can enhance students' ability to solve real-life problems. However, data show that Indonesian students' scientific literacy skills remain low (Akbarudin & Kurniawati, 2023).

According to the 2022 PISA results, Indonesia ranked 67th out of 81 countries in science, with an average score of 383, which is below the international average. Although

Indonesia's ranking rose 5-6 positions compared to 2018, its science literacy score decreased by 12 points. This result suggests that a rise in ranking does not always correspond to an improvement in students' science literacy. Several factors causing low science literacy in Indonesia have been identified through literature studies. According to Yusmar et al., (2023), factors causing low science literacy in students include: 1) students do not understand the basic science concepts taught by teachers, but are reluctant to ask questions; 2) science learning in schools is still carried out conventionally; 3) students' lack of ability to interpret tables or graphs; 4) ignoring the importance of reading/literacy and writing skills as mandatory competencies for students; and 5) students' lack of interest in reading and reviewing learning materials. This analysis highlights the need for improvements through effective learning models to enhance students' science literacy. In line with research by Kamariah et al. (2023), which states that the project-based learning model is effective in improving students' scientific literacy. The project-based learning (PjBL) model provides space for students to actively engage in the learning process actively, increasing their interest and understanding of science (Hussein, 2021). However, the project-based learning model employs a differentiated approach that can accommodate students' diverse learning interests and styles (Wang & Wang, 2023). The learning process, according to the independent curriculum, emphasises learning that can be integrated with differentiated learning.

The concept of differentiated learning is an ideal idea, so its implementation presents a challenge for teachers to be creative. One challenge faced is the need for teachers to understand the various characteristics of students, which is certainly not easy (Mayasari & Paidi, 2022) . Furthermore, teachers must also develop diagnostic and formative assessments at the beginning of the lesson, and utilise various methods, multimedia, and information sources (Sufanti et al., 2022).

Differentiated learning is a manifestation of student-focused learning that accommodates or considers students' readiness to learn (readiness), learning interests, and learning profiles (Marantika et al., 2023). Learning style is one aspect that contributes to student learning success. Therefore, if a project-based differentiated learning model is implemented, of course, with an eye to learning styles, it is expected to support the improvement of students' scientific literacy.

Biotechnology is considered a suitable topic for implementing the differentiated project-based learning (PjBL) model because it allows students to hone their scientific literacy skills. Biotechnology covers issues relevant to everyday life and technological developments, thereby increasing student interest and understanding. Research has shown that Socio-Scientific Issues (SSI)-based teaching materials for biotechnology can improve students' scientific literacy. Therefore, the use of biotechnology materials in PjBL is expected to be an effective strategy for improving students' scientific literacy in Sleman. Researchers observed that some students lacked focus on the material and were distracted by conversation, making it difficult for them to provide answers to questions posed by the teacher. Furthermore, students were still confused about how to express their opinions or ideas during the learning process. This condition was due to students' lack of understanding and interest in the material, as well as their distractions from playing with gadgets and chatting during the lesson. Lack of active student engagement in the learning process can also be a determining factor, where less intense interaction between students and the learning material may lead to a lack of in-depth understanding (Sudrajat et al., 2024).

Based on the explanation presented, this study aims to examine the effect of a differentiated project-based learning model on the scientific literacy of 10th-grade students at SMAN 1 Turi in the field of biotechnology, taking learning styles into account. Through this study, it is hoped that a deeper understanding of the relationship between learning approaches, scientific literacy, and learning styles can be gained, as well as efforts to achieve educational equality through the implementation of innovative learning models. This study differs from previous research, which only examined the impact of the project-based learning (PjBL) model on students' scientific literacy skills. This study integrates the PjBL model with gender-based analysis of students to evaluate their level of scientific literacy in the material.

METHOD

Research Design

This research employs a quasi-experimental design. This study used one class in the control group and one in the experimental group. The experimental class received treatment in the form of a project-based, differentiated learning model. At the same time, the control group was given a discovery learning model commonly used by teachers in schools. The research design used for both treatments was a non-equivalent control group design. The control class and the experimental class were randomly selected and then administered a pre-test to measure students' initial scientific literacy abilities. A post-test was administered after receiving treatment to measure their scientific literacy abilities.

This research will last for one month, from August 28, 2024, to September 30, 2024. The implementation time was chosen to align with the material taught, namely biotechnology, in the first semester of grade X, based on the Independent Curriculum. The research location is SMAN 1 Turi in the odd semester of the 2024/2025 academic year. The selection of SMAN 1 Turi as the research location is based on the lack of similar research development at the school.

Research Population and Sample

The population in this study consisted of all grade X students at SMAN 1 Turi who received Biology lessons in the 2024/2025 academic year, totalling 140 students and spread across 4 classes, each class consisting of 35 students. The sample in this study consisted of 68 students, divided into two classes: E1 and E2, each with 34 students.

Research Procedures

Research preparation begins with the creation of an observation letter, followed by the development of research instruments, including a learning style test, a differentiated learning module, student worksheets tailored to learning styles, observation sheets, implementation sheets, and test instruments for the pre-test and post-test. Validated instruments can then be used as research tools.

Data Collection Technique

Data collection techniques used tests and non-tests. The test technique utilises instruments to measure scientific literacy through pre-tests and post-tests. Meanwhile, the non-test technique uses observation sheets to collect data directly from the field, and a questionnaire containing several written questions is used to obtain information regarding the grouping of student learning styles.

Data Analysis Techniques

This study employed descriptive and inferential data analysis techniques. Descriptive analysis was used to describe the research results. The inferential analysis used was the T-test. The T-test used two categories: the Independent Sample T-Test (unpaired) and the Paired Sample T-Test (paired) in the SPSS 27.0 program. The T-test was used to determine the effectiveness of the learning conducted.

RESULTS AND DISCUSSION

Results

Results of Observations on Learning Implementation

Learning implementation data was obtained through observations conducted during the learning process in both the experimental and control groups. The results of the learning implementation in the two groups are presented in Table 1.

Table 1. Results of learning implementation

Gorup	Meeting	Percentage	Category
Experimental	1	80.00%	Good
	2	86.67%	Good
Control	1	78.00%	Good
	2	78.00%	Moderate

Based on the data tabulation, it was found that the implementation of a differentiated project-based learning model on biotechnology material, based on learning styles, was successful in the experimental group. Meanwhile, in the control group, learning using a project-based learning model that did not consider learning styles, but employed the STEAM approach, was also successful. However, there was a decline in achievement at the second meeting.

Results of Students' Science Literacy Skills Before and After Treatment

Students' Science Literacy scores were obtained through pre-test and post-test results for the control and experimental groups. These results were then tabulated in Table 2.

Table 2. Results of pre-test and post-test of students' science literacy skills

Statistic	Gorup			
	Control		Experiment	
	Pre-test	*Post-test*	*Pre-test*	*Post-test*
Mean	29,91	31,41	26,44	37,88
Standard Deviation	11,60	12,44	15,41	7,71
Minimum	0,0	8,0	0,0	23,00
Maximum	46,0	54,0	54,0	54,0

From the tabulation of the results data, it is evident that the average results (mean) in the experimental group tend to be higher than those in the control group. To determine the difference in the value (significance) of Scientific Literacy in the control group and the experimental group, an inferential statistical analysis was conducted to determine the effect of the application of differentiated learning with the Project-based Learning model of biotechnology material reviewed from learning styles and the Project-based Learning model of biotechnology material not reviewed from learning styles (experimental group) on the Scientific Literacy of students (control group).

Scientific Literacy Skills Results Reviewed from Different Learning Styles

To determine differences in Science Literacy scores based on learning styles, a pre-test and post-test were conducted. The results of the science literacy scores, based on learning styles, are presented in Table 3.

Table 3. Scientific literacy skills viewed from different learning styles

Group	*Pre-test*			*Post-test*		
	Visual	Auditory	Kinesthetic	Visual	Auditory	Kinesthetic
Experiment	26,04	19,33	36,8	36,88	41,00	35,00
Control	28,26	37,80	31,00	26,46	39,60	28,31

Table 15 shows that the Science Literacy scores of students with different learning styles increased. The Science Literacy scores of students with visual learning styles were relatively higher than those with auditory and kinesthetic learning styles. Further statistical testing is needed to determine the significance of this improvement.

Prerequisite Test Results

Normality Test Results

The results of the normality test, carried out using the Kolmogorov-Smirnov test, are presented in Table 5.

Table 5. Normality test

Variable	Group	Statistic	Sig. Kolmogorov-Smirnov	Interpretation
Science Literacy	*Pre-test*_Experiment	0.105	0.134	Normally Distributed
	*Post-test*_Experiment	0.133	0.200	Normally Distributed
	*Pre-test*_Control	0.106	0.200	Normally Distributed
	*Post-test*_Control	0.125	0.167	Normally Distributed

Based on the results of the normality test for the experimental group and the control group using the Kolmogorov-Smirnov test, the obtained values were significant ($p > 0.05$), indicating that the data are normally distributed.

Homogeneity Test

The results of the homogeneity test are presented in Table 6.

Table 6. Post-test homogeneity test of experimental and control groups

Variable	Group	Sig.	Category
Science Literacy	*Post-test of experimental and control groups*	0.428	Homogen

Based on the results obtained from the homogeneity of variance test (Test of Homogeneity of Variance), it is known that the significance value based on the Mean is 0.472, which is greater than 0.05. This result indicates that the Post-test data in the experimental and control groups are homogeneous. Therefore, it can be concluded that the Post-Test Variances of the experimental and control groups are the same.

Hypothesis Testing

Hypothesis testing can be conducted if the prerequisites have been met. A parametric statistical test is used to determine the results of a hypothesis test, namely the t-test. The results of the independent sample t-test are presented in Table 7.

Table 7. Independent sample t-test results

Data	Sig. (2-tailed)
Post-test values of the experimental and control groups	0.001

Based on the data presented in Table 7, it can be concluded that the Post-test value of the experimental group and the control group is 0.001, which means <0.05. This result indicates a significant difference in the average scientific literacy of students, suggesting that H0 is rejected and H1 is accepted. This result indicates that the project-based differentiated learning model has an impact on the scientific literacy of students, particularly in terms of their diverse learning styles.

DISCUSSION

The research results show that the application of a differentiated project-based learning model to biotechnology material has a significant impact on improving students' scientific literacy. This model employs an approach that integrates direct student involvement through projects, the exploration of real-world problems, and the development of innovative solutions (Khuzaimah et al., 2025). In the context of this study, the experimental group demonstrated higher average scientific literacy outcomes than the control group, as shown in the pre-test and post-test results tables. In a study on the implementation of the Project-Based Learning (PBL) model, observations were conducted on two groups of students: the experimental group and the control group. The purpose of this study was to evaluate the effectiveness of PBL tailored to students' learning styles compared to the implementation of PBL without such differentiation.

In the experimental group, the PBL approach was implemented, taking into account each student's individual learning style. The observations showed significant progress. In the first meeting, learning implementation reached 80%, and this figure increased to 86.67% in the second meeting. This improvement reflects the positive impact of implementing PBL based on learning styles in increasing student engagement (Desi et al., 2023). On the other hand, the control group implemented a PBL model without differentiation based on student learning styles. The learning implementation rate in this group was relatively stable, at 78% in the first meeting and remained the same in the second meeting. Although the technical approach used was the same, the results showed that several issues hindered learning success in the control group (Krisgiyanti & Pratama, 2023).

The most prominent issue was low student engagement during discussions, which was often hindered by distractions caused by the use of irrelevant gadgets (Zulfah et al., 2025). Without adjustments to individual needs, learning motivation in this group did not significantly increase (Sunarmi et al., 2023). The analysis showed that the experimental group had a higher average Science Literacy score than the control group. In the experimental group, the average post-test score reached 37.88, compared to only 29.91 for the control group. This result indicates that a learning model that considers students' learning styles has a more significant impact on improving Science Literacy (Amalia, et al., 2023).

Scientific literacy is a vital skill for students in the modern era, particularly with the rapid advancement of technology and information (Saefi et al., 2025). Scientific literacy encompasses the ability to comprehend scientific concepts, apply scientific methods, and make informed decisions based on scientific evidence (Sari et al., 2022). However, improving scientific literacy cannot be achieved without considering the diverse learning styles of students (Mayasari & Paidi, 2022).

This study used a differentiated project-based learning approach that considers visual, auditory, and kinesthetic learning styles. These learning styles influence how students receive, understand, and apply information, making them key factors in successful learning (Lestari & Rakhmawati, 2024). The results showed that implementing project-based learning with a differentiated approach yielded better results than approaches that did not consider learning styles (Munthe et al., 2023). Based on observations of learning implementation, the experimental group using the differentiated approach achieved an average observation score of 83.34%, which is considered good. In contrast, the control group, which used project-based learning without considering learning styles, achieved an average observation score of 78%, with several challenges, including a lack of active student participation.

The success of this differentiated learning model can be attributed to the method's flexibility, which enables students with diverse learning styles to engage actively. For example, students with a visual learning style are better able to understand concepts through pictures and diagrams. In contrast, students with a kinesthetic learning style tend to be more engaged through practical activities. Data analysis showed a significant increase in scientific literacy scores in the experimental group compared to the control group. In the experimental group, the average post-test scores for students with a visual learning style, auditory learning style, and kinesthetic learning style were 36.88, 41, and 35, respectively. This result indicates that the differentiated approach not only improves overall scientific literacy but also effectively accommodates diverse learning styles.

Conversely, in the control group, students with a visual learning style recorded an average post-test score of 26.33, auditory learners recorded 39.60, and kinesthetic learners recorded 28.31. These data indicate that without a differentiated approach, students with kinesthetic and visual learning styles tend to achieve less than optimal scientific literacy. Statistical tests revealed that the research data were normally distributed, with a significance value greater than 0.05, as determined by the Kolmogorov-Smirnov test. Furthermore, the homogeneity test also showed that the data were homogeneous with a significance value of 0.428. These results provided the basis for conducting an independent t-test to determine the significant effect of the differentiated learning approach. The t-test results showed a significant difference in the average scientific literacy between the experimental and control groups ($p < 0.05$). This result confirms that the differentiated approach has a significant influence on improving scientific literacy.

CONCLUSION

Based on this study, it is demonstrated that the application of a project-based differentiated learning model to biotechnology material has a significant impact on enhancing students' scientific literacy. The experimental group that received the differentiated learning model treatment showed a higher average scientific literacy result than the control group, as evidenced by both observations of learning implementation and the results of the Pre-test and post-test assessments. With the results of statistical tests showing a significant difference ($p < 0.05$), it can be concluded that this model is effective in improving scientific literacy. The project-based differentiated learning model proved more effective in improving students' scientific literacy in the experimental group, which included students with various learning styles (visual, auditory, kinesthetic), compared to the control group that did not employ differentiation. The results showed that students with an auditory learning style achieved the highest average score (41), followed by those with a visual learning style (36.88), and then those with a kinesthetic learning style (35). In contrast, in the control group, the highest average score was achieved only by students with an auditory learning style (39.60), while students with visual and kinesthetic learning styles each recorded lower scores (26.33 and 28.31, respectively). With these results, it can be concluded that the project-based differentiated learning model is not only effective in improving overall scientific literacy but also able to accommodate differences in student learning styles, with the most significant results observed in students with an auditory learning style.

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