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THE IMPACT OF PROJECT-BASED LEARNING ON STUDENTS' SCIENTIFIC LITERACY AND AUTONOMY

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Abstract. Scientific literacy and autonomy are crucial for students to cope with 21st-century learning demands, where educators need to innovate the learning process. This serves as the rationale for analyzing the impact of Project-Based Learning (PjBL) on scientific literacy and autonomy among fourth-grade elementary school students. The research design employed a quasi-experimental design with a sample size of 58 participants. Data collection utilized both test and questionnaire methods. The test instrument consisted of 20 essay questions to assess scientific literacy, while the questionnaire comprised 30 statements to measure autonomy. Data analysis methods included quantitative descriptive analysis and inferential statistical analysis, employing MANOVA with a result of $0.00 < 0.05$. Based on the analysis, Project-Based Learning (PjBL) significantly influences both scientific literacy and autonomy of the students, both simultaneously and partially. This is evidenced by the difference in mean values, where the mean values of scientific literacy and student autonomy taught through PjBL were higher. The research findings also indicate that scientific literacy was more significantly influenced compared to student autonomy. Therefore, it can be recommended as an innovative learning approach to enhance both scientific literacy and student autonomy.

INTRODUCTION

Education in the 21st-century paradigm is crucial for every individual to undertake (Khoiriyah & Husamah, 2018). This activity, whether consciously or unconsciously, is pursued to achieve specific goals. In the current educational context, the learning process is highly associated with literacy skills. Entering the 21st century, literacy is considered a form of communication skills encompassing reading, speaking, listening, and writing. Literacy serves as the foundation for instilling noble values in learners (Rachmawati et al., 2019). Moreover, literacy plays a significant role in accessing oral and written information, developing critical thinking skills in problem-solving, and enhancing sensitivity to the surrounding environment (Ke et al., 2021). One important aspect of literacy is scientific literacy. Scientific literacy is crucial in the modern era filled with science and technology-related issues (Semilarski & Laius, 2021; Valladares, 2021; Widodo et al., 2020). Scientific literacy needs to be cultivated as every individual requires scientific information in daily life as a basis for scientific thinking, decision-making, and problem-solving (Chusni & Hasanah, 2018; Samsu et al., 2020; Wahyu et al., 2020). Scientific literacy also supports the development of responsibility towards environmental awareness, interest, motivation, and learner engagement (Oliver & Adkins, 2020). Literacy skills themselves encompass the use of knowledge and scientific processes in problem-solving (Fadila et al., 2020; Rusilowati et al., 2018; Sudarsono et al., 2020; Widi et al., 2016). Scientific literacy is necessary for developing scientific knowledge, identifying problems, and drawing conclusions based on real evidence found through the verification process (Fauziyah et al., 2021). Thus, scientific literacy is a highly essential skill today (Purnadewi & Widana, 2023). With scientific literacy, learners can develop their knowledge, skills, and attitudes towards scientific and technological advancements, as well as enhance their environmental awareness.

In addition to scientific literacy, another crucial skill in 21st-century learning is Autonomy. Learners with good autonomy no longer require continuous encouragement from educators (Shepley et al., 2018). Independent learners are those who can manage their own learning to achieve goals, not entirely relying on educators, more motivated to learn, and capable of reflecting on their own learning (Nguyen & Habók, 2021). Autonomy is often associated with positive attitudes towards individual values and self-expression (Magnusson & Zackariasson, 2019). Learner Autonomy can be measured through several indicators, such as self-awareness, understanding of the situation faced, and self-regulation. Learner Autonomy can be developed through planning, organization, and evaluation of learning (Tseng et al., 2020). Autonomy is gained from active and effective learning experiences (S. Orakci & Gelisli, 2019; Ş. Orakci & Gelisli, 2017). The improvement of learner Autonomy also impacts their cognitive abilities negatively (Orakcı, 2021). Therefore, educators need to develop active learning, considering that autonomy can be obtained through planning, implementation, and evaluation of learning that focuses more on developing learners' 21st-century skills (Tseng et al., 2020). Thus, Autonomy is an important skill that learners must possess to face technological advancements.

However, low scientific literacy hinders the development of science and technology and impacts the lack of sensitivity to environmental damage caused by the negative effects of technological advancements (Zainuri et al., 2022). On average, students' scientific literacy is still not optimal, only covering content understanding and not yet able to communicate and connect their abilities with everyday problems (Wibowo & Ariyatun, 2020). Scientific literacy among students in Indonesia is still low, and the textbooks used are not effective in training students to understand the essence of science (Chusni & Hasanah, 2018). The low understanding of scientific concepts among students is often associated with learning methods that are still oriented towards memorization, conventional methods, and high levels of material difficulty (Ariana et al., 2020). This research indicates that the learning activities implemented by teachers are less innovative and creative, and still use conventional approaches without considering the activeness of learners (Pujawan et al., 2022). Initial analysis also shows that the scientific literacy skills of students are still quite low, exacerbated by the low Autonomy of students in learning. One indicator is that students tend not to learn if there is no guidance in the learning process. This condition reflects the need for a change in more interactive learning methods and encourages active student participation to enhance understanding and Autonomy in learning. To address this issue, appropriate solutions are needed. The development of scientific literacy and Autonomy can be enhanced through the use of innovative learning media and creative teaching methods (Cahyana et al., 2019). The solution is the Project-Based Learning model. Project-Based Learning (PjBL) is a recommended instructional model for teachers to support the implementation of a scientific approach in the 2013 curriculum. Through

PjBL, students are engaged in experiential learning, where they learn through direct experiences. This model involves students in solving real-life problems encountered in their daily lives within the context of learning, with solutions presented in the form of projects(Hernáiz-Pérez et al., 2021; Kurniawan et al., 2018; Muhammad, 2018). PjBL provides students with the opportunity to work independently in constructing their own knowledge and producing tangible products(Chu et al., 2017; Rahmazatullaili et al., 2017). Problem-focused learning and projects encourage students to develop higher-order thinking skills and provide space for them to express creative ideas about the projects they are working on(Efendi et al., 2020; Lestari, 2021; Sasson et al., 2018; Susanto et al., 2020). Through PjBL, students can enhance critical thinking skills by facing and solving real-world problems. Additionally, PjBL stimulates student creativity as they are required to think innovatively in completing tasks (Noviyana, 2017; Syarifah & Emiliasari, 2019; Wulandari et al., 2019). PjBL can improve scientific literacy (Safaruddin et al., 2020; Surya et al., 2018; Tesi Muskania & Wilujeng, 2017), high-level thinking skills (Evi Yupani & Widana, 2023; Winarni, 2019), and overall learning outcomes because students are engaged in exploration and in-depth research. Furthermore, PjBL can enhance student character, promote cooperation and collaboration in project completion, thus strengthening collaboration skills, numeracy literacy, and digital literacy. PjBL is effective in improving students' soft skills if supported by adequate facilities.

Based on the explanation provided, this research aims to analyze the impact of Project-Based Learning (PjBL) on students' scientific literacy and autonomy. The main reason for this research is that PjBL has been proven effective in developing various 21st-century skills such as critical thinking, creativity, and collaboration. Scientific literacy and Autonomy are two crucial skills needed to tackle challenges in the continuously evolving era of science and technology (IPTEK). This research has several significant differences compared to previous studies. Firstly, it focuses on learning specifically designed with problems relevant to students, making it more contextual and meaningful to them. This differs from previous approaches that may use more general or less relevant problems. Second, this research combines two main variables, scientific literacy and autonomy, which have not been extensively explored together in the context of PjBL. Scientific literacy is essential for understanding and applying scientific concepts in everyday life, while relating to students' ability to manage their own learning without relying on continuous guidance from instructors. By combining these two variables, this research is expected to provide a more comprehensive overview of how PjBL can improve both aspects simultaneously. Additionally, this research also aims to identify the best methods and strategies in implementing PjBL that can optimize the improvement of students' scientific literacy and Autonomy. The results of this research are expected to make a meaningful contribution to curriculum development and learning practices in higher education, as well as providing practical recommendations for instructors to enhance their teaching effectiveness.

METHOD

This study utilizes a quasi-experimental design known as nonequivalent post-test only control group design (Rogers & Revesz, 2019). In the implementation of the research, the experimental group was treated with Project-Based Learning (PjBL), while the control group was treated with a non-PjBL approach. Both groups, experimental and control, were given a post-test to determine the difference in scientific literacy and autonomy between the experimental group treated with PjBL and the control group. The data to be obtained in this study are (1) Scientific literacy (Y1) of students taught using PjBL; (2) Scientific literacy (Y1) of students taught using non-PjBL approach; (3) autonomy ability (Y2) of students taught using PjBL; and (4) autonomy ability (Y2) of students taught using non-PjBL approach. The research consists of three stages: preparation stage, implementation stage, and final stage or completion of the experiment.

The population in this study consists of all elementary education students majoring in basic science concept development, totaling 120 students spread across four classes. After conducting equivalence testing using One Way-ANOVA (ANAVA-A) with SPSS 25.0 for Windows application, simple random sampling technique is performed through lottery to select two classes as research samples. Class C and B were chosen from the lottery. Subsequently, another lottery was conducted to determine the experimental and control classes. As a result, class B was designated as the experimental group with 23 students receiving PjBL treatment, while class C was designated as the control group with 25 students not using the PjBL model.

In this study, data collection was conducted using both test and questionnaire methods. The test method is a way to directly assess individuals' abilities through their responses to a series of stimuli or questions (Evayanti & Sumantri, 2017). The test method was employed to measure the effectiveness of the Project-Based Learning (PjBL) model on students' science literacy. The test instrument consisted of essay questions designed to assess students' improvement in science literacy. To ensure the validity of the instrument, several steps were taken: 1) developing the test instrument matrix, 2) creating questions in essay form, and 3) consulting on the test matrix. Although the designed test instrument consisted of 12 items, students were given 20 items in the test.

Data collection through a questionnaire was used to measure students' self-reliance. The questionnaire included five answer choices: strongly agree, agree, neutral, disagree, and strongly disagree. The instrument consists of 30 items covering 2 dimensions with 11 indicators. The second dimension included: 1) self-awareness and situational awareness, and 2) self-regulation. In testing the validity of the questionnaire instrument, tests were conducted on the validity of item instruments, content validity, and reliability. Validity was measured using the Content Validity Ratio (CVR) formula. The CVR calculation results for each item instrument were 1, and the overall CVR for all items of science literacy ability was 30, indicating validity based on the validation criteria for each item instrument in the CVR formula. The validity test of the questionnaire content using SPSS showed a result of 0.85, which falls into the category of very strong. Reliability testing of the questionnaire using SPSS resulted in a Cronbach's Alpha value of 0.81, indicating that the developed questionnaire is highly reliable.

The data collection method in this study involved descriptive analysis and inferential statistical analysis. Descriptive analysis was processed using SPSS 26.0 for Windows and involved post-test data analysis. The values sought in the statistical test include mean, standard deviation, maximum value, and minimum value. For inferential analysis, the Multivariate Analysis of Variance (MANOVA) test was used on the post-test data. Before conducting the MANOVA test, swimming tests were performed, including normality tests with Kolmogorov-Smirnov, homogeneity tests with Levene's Statistics and Box's Test of Equality of Covariance Matrices, and multicollinearity tests. All swimming tests and MANOVA tests were conducted using SPSS 25.0 for Windows.

RESULTS AND DISCUSSION

After being implemented according to the instructional design, the research findings indicate an improvement in science literacy and self-reliance among students who participate in learning with the Project-Based Learning (PjBL) model. The detailed results of the descriptive analysis are presented in Table 1. The research findings show a significant difference in the science literacy and self-reliance of students between the group taught with the Project-Based Learning (PjBL) model and the group that did not. This difference is reflected in the different mean values between the two groups. For example, there is a difference of 5.14 in science literacy between students who received instruction with the Project-Based Learning (PjBL) model and those who did not. The mean value of science literacy in the group that participated in learning with the Project-Based Learning (PjBL) model was higher than the other group. Similarly, for student self-reliance, there is a difference of 3.32 between the group taught with the Project-Based Learning (PjBL) model and the group that did not. The mean value of student self-reliance in the group using the Project-Based Learning (PjBL) model is also higher. The research results also indicate that the science literacy variable is more influential than self-reliance, as evidenced by the larger difference in mean literacy values (Widana & Ratnaya, 2021). This indicates that the use of the Project-Based Learning (PjBL) model effectively enhances students' science literacy.

Table 1. Results of descriptive analysis of scientific literacy and Autonomy

Treatment	Variabel Terikat	Mean	Standar deviasi	Maksimum	Minimum
Project Based Learning Model (PjBL)	Scientific Literacy	76.89	3.348	81	71
	Autonomy	64.47	3.49	70.00	60.00
Model Not a Project Based Learning (PjBL) model	Scientific Literacy	61.75	2.826	66	55
	Autonomy	61.15	5.09	69.00	54.00

The prerequisite analyzes conducted include testing for the normality of data distribution, homogeneity of variances, multivariate homogeneity, and linearity of dependent variables. The first prerequisite test is the normality test using the Kolmogorov-Smirnov method. The analysis results show that all data come from groups with a normal distribution, as reflected in the Sig. values > 0.05. Specifically, it is 0.156 for literacy in science with PjBL treatment, and 0.157 for literacy in science without treatment. As for Autonomy given treatment, it is 0.156, and without treatment is 0.155. After ensuring the normality condition is met, the next prerequisite test is the homogeneity test. In this study, homogeneity testing was conducted through two analyses, namely the homogeneity of variances test using Levene's Test of Equality and the multivariate homogeneity test using Box's Test of Equality of Covariance Matrices. The homogeneity analysis results show that the research data come from homogeneous data groups, as indicated by Sig. values greater than 0.05 for each test. The Sig. value from Levene's Test of Equality for literacy in science is 0.05, while for Autonomy ability, it is 0.453. Additionally, the homogeneity test using Box's Test of Equality of Covariance Matrices provides a Sig. value of 0.722 with an F value of 0.842. Further testing is conducted for multicollinearity. The analysis results show that the Variance Inflation Factor (VIF) and tolerance values are close to 1, indicating no significant correlation between literacy in science and Autonomy. Thus, the initial analysis for MANOVA has been met, as the research data are normally distributed, homogeneous, and there is no linear relationship between variables. Therefore, hypothesis testing with MANOVA can be performed. The complete analysis results are listed in Tables 2 and 3.

Table 2. Results of Manova Test Analysis

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	1.00	7613.16[b]	2.00	58.00	0.00
	Wilks' Lambda	0.00	7613.16[b]	2.00	58.00	0.00
	Hotelling's Trace	434.06	7613.16[b]	2.00	57.00	0.00
	Roy's Largest Root	434.06	7613.16[b]	2.00	58.00	0.00
Group	Pillai's Trace	0.79	135.44[b]	2.00	58.00	0.00
	Wilks' Lambda	0.11	135.44[b]	2.00	58.00	0.00
	Hotelling's Trace	5.08	135.44[b]	2.00	58.00	0.00
	Roy's Largest Root	8.08	145.44[b]	2.00	58.00	0.00

Based on the analysis results, several findings were obtained. First, the MANOVA results show Pillai's Trace, Wilks' Lambda, Hotelling's Trace, and Roy's Largest Root, with an F coefficient of 7613.16 and a Sig. value of 0.00. This indicates that there is a simultaneous difference in science literacy and Autonomy among the student groups taught using the Project-Based Learning (PjBL) model. Second, the analysis of Tests of Between-Subjects Effects shows an F value of 4.13 with a Sig. value of 0.03, which is smaller than 0.05. This indicates that there is an influence of the Project-Based Learning (PjBL) model on science literacy. Third, the analysis of Tests of Between-Subjects Effects shows an F value of 133.89 with a Sig. value of 0.000, which is smaller than 0.05. This indicates that there is an influence of the Project-Based Learning (PjBL) model on student Autonomy.

Table 3. Results of Tests of Between-Subjects Effects analysis

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Scientific Literacy	95.07[a]	1	95.07	4.13	0.03
	Autonomy	1234.82[b]	1	2234.82	133.89	0.00
Intercept	Scientific Literacy	144256.61	1	154256.61	8328.62	0.00
	Autonomy	157294.82	1	187294.82	19601.51	0.00
Group	Scientific Literacy	95.07	1	95.07	5.13	0.03
	Autonomy	2234.82	1	2234.82	233.89	0.00
Error	Scientific Literacy	685.29	57	18.52		
	Autonomy	353.54	57	9.56		
Total	Scientific Literacy	154942.00	59			
	Autonomy	188958.000	59			
Corrected Total	Scientific Literacy	780.36	58			
	Autonomy	2588.36	58			

The research findings indicate that the Project-Based Learning Model (PjBL) has an effect on science literacy and student autonomy. This is evident from the improvement in science concepts and student autonomy. This condition is undoubtedly influenced by the stages of learning. Project-Based Learning (PjBL) is tailored to the characteristics of the students. Learning with this model creates a more comfortable learning atmosphere because students are supported by a suitable learning model. Students are given problems that they encounter in their daily lives. This type of learning undoubtedly makes students more interested in participating in the learning process. Students who are interested in the learning process will increase their interest in learning (Fajri et al., 2021; Yuliansih et al., 2021). With interest in learning, this will impact the involvement of students in the learning process. Students will happily gather all information related to the material provided, which will certainly affect their improvement in science concepts. Learning activities provide students with the opportunity to develop science process skills (Pujawan et al., 2022). With the development of scientific processes, students will gain knowledge about science. In other words, students' ability to solve problems using scientific processes will impact their science literacy.

Scientific literacy is highly essential in modern life, particularly when dealing with issues related to science and technology (Semilarski & Laius, 2021; Valladares, 2021; Widodo et al., 2020). Scientific literacy is crucial in preparing individuals because everyone needs information in their daily lives as a reference for scientific thinking and decision-making (Semilarski & Laius, 2021; Valladares, 2021; Widodo et al., 2020). Scientific literacy is vital in supporting the development of attitudes, environmental awareness, responsibility, interest, motivation, and student engagement (Oliver & Adkins, 2020). The ability of literacy enables individuals to use scientific knowledge and processes to solve problems (Fadila et al., 2020; Rusilowati et al., 2018; Sudarsono et al., 2020; Widi et al., 2016). Scientific literacy is necessary to develop scientific knowledge, identify problems, and draw conclusions based on verifiable evidence (Fauziyah et al., 2021). In this research, scientific literacy flourished because students were directly involved in the learning process, and the learning was more focused on how students solve problems. Additionally, students did not feel bored because the learning materials were presented through engaging media.

The research indicates that the Project Based Learning Model (PjBL) significantly influences student autonomy in learning (S. Orakci & Gelisli, 2019; Ş. Orakci & Gelisli, 2017). This occurs because the model emphasizes presenting real-world problems with technology that suits students' development, allowing more flexible access for them. In this process, students can develop awareness and understanding of the situations they face. The focus on students in the learning activities makes them more active and fosters autonomy. This aligns with the view that active and effective learning experiences promote the development of student autonomy. Student autonomy is also associated with the ability to manage their own learning, intrinsic motivation, and self-reflection (Shepley et al., 2018; Tseng et al., 2020). In this context, autonomy also relates to positive attitudes toward individual values and self-expression (Magnusson & Zackariasson, 2019). Problem-solving learning in this model encourages students to think critically, not just accept opinions without confirmation, and focus more on developing ideas based on scientific evidence. Self-assessment also becomes an important part of this learning process, which can enhance students' abilities as learners (Daulay & Daulay, 2020; Nguyen & Habók, 2021).

This elaboration provides a detailed overview of the positive impact of the Project Based Learning Model (PjBL) on the learning process. The study successfully highlights new advantages by focusing on the direct influence of the Project Based Learning Model (PjBL) on students' scientific literacy and autonomy. The research findings indicate that the use of this model has a significant impact, particularly on enhancing students' scientific literacy, which includes a deeper understanding of scientific concepts and the ability to apply scientific knowledge in real-life contexts. Additionally, the model also results in improvements in the scientific explanation process, demonstrating that students are more engaged in exploration and discovery of knowledge through a scientific inquiry approach. However, the study has limitations related to the limited sample size. Although promising results were obtained, the generalization of research findings may be limited by the specificity of the school and student context. Therefore, further research involving more schools is needed to broaden the scope and validity of the findings. Thus, it would ensure that the impact of implementing the Project Based Learning Model (PjBL) on students' scientific literacy and autonomy could be more accurately measured and applied more widely in diverse educational contexts.

CONCLUSION

The research findings indicate that the use of the Project Based Learning Model (PjBL) has a positive impact on students' scientific literacy and autonomy. This model enhances students' understanding of scientific concepts and their engagement in learning. The scientific literacy acquired through this model enables students to apply scientific knowledge in their daily lives. Recommendations for further development include conducting additional studies with a larger sample size to strengthen these findings. Moreover, project-based learning approaches can be more widely integrated into the curriculum to enhance students' scientific literacy in various educational contexts.

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