Improvement of Scientific Literacy Skills in the Human Excretory System for Junior High School Students through Project-Based Learning

Grace Angeline Manurung, Mariati Purnama Simanjuntak, and Saidatunnisa Nasution

Universitas Negeri Medan, Medan, Indonesia

mariatipurnama@unimed.ac.id

Abstract. In the modern era, possessing scientific literacy skills is crucial for students to tackle global issues, yet many students currently lack proficiency in this area. Project-based learning stands out as a promising approach to cultivate these skills, as it encourages students to improve their scientific literacy abilities actively. This study aims to investigate how project-based learning impacts the science literacy skills of eighth-grade students, focusing specifically on the Human Excretory System. Conducted during the even semester of the 2022-2023 academic year, this research employed a quasi-experimental design with two groups: VIII-1, which implemented project-based learning, and VIII-4, which followed conventional teaching methods, with each group comprising 29 students selected through simple random sampling. The research utilized a scientifically designed test with 20 multiple-choice items. The results indicated significant improvement in the scientific literacy of students in the experimental group, with pretest and post-test averages of 27.24 and 80.67, respectively, compared to the control group's averages of 22.50 and 52.83. Statistical analysis through t-tests confirmed the substantial impact of project-based learning, particularly in understanding the Human Excretory System, emphasizing the importance of integrating activities in each session to enhance learning outcomes, especially through hands-on activities that are particularly effective in developing scientific literacy skills.

Keywords: project-based learning, scientific literacy, Human Excretory System

1 Introduction

Learning in the 21st century is intricately linked to the advent of the Industrial Revolution 4.0, significantly impacting the realm of education [1]. Education plays a pivotal role in human survival [2]. Within this context, scientific literacy emerges as a fundamental competency that students must possess in the modern era. Students endowed with robust scientific literacy not only cultivate their character and behavior but also develop a mindset oriented towards personal, societal, and universal care and responsibility [3]. Proficient in scientific literacy, students can effectively tackle

P. C. Kuswandi et al. (eds.), *Proceedings of the 6th International Conference on Current Issues in Education (ICCIE) 2023*, Advances in Social Science, Education and Humanities Research 847,
https://doi.org/10.2991/978-2-38476-245-3_30

problems and make informed decisions using their knowledge and leveraging technology at their disposal.

According to the Program for International Student Assessment (PISA), scientific literacy entails individuals' ability to engage with science-related issues employing scientific concepts while embodying reflective citizenship [4]. It encompasses an understanding of events and phenomena in the surrounding environment [5] and empowers individuals to identify problems, draw evidence-based conclusions, and navigate through human activities [6], [7].

Scientific literacy assumes paramount importance in addressing global challenges of the 21st century, necessitating the cultivation of such skills among students through science education [8]. This goes beyond merely grasping scientific concepts, emphasizing instead on the capacity of individuals to make informed decisions and actively participate in social spheres utilizing scientific principles [8]. Given its significance, fostering scientific literacy stands as a cornerstone goal in the reform of science education [9], [10], being deemed an essential foundational skill for every individual [8], [11]. PISA delineates scientific literacy skills to include explaining scientific phenomena, designing and evaluating scientific investigations, and interpreting scientific data and evidence [12].

However, Indonesia's PISA scores in 2022 revealed a deficiency in scientific literacy skills among its students, trailing behind the international average [13]-[15]. This underscore concerns about the future competitiveness of Indonesian students in the global arena. The low levels of scientific literacy may stem from various factors such as teachers' understanding of scientific literacy, inadequacies in learning models and materials, and the absence of scientific literacy-based assessments [16]-[18].

Observations and interviews in several junior high schools in Medan corroborate the deficiency in students' scientific literacy skills, with science learning often neglecting to incorporate scientific literacy elements. Conventional teaching methods, teacher-centric learning approaches, and limited exposure to laboratory activities further compound the issue [19].

Addressing this gap in scientific literacy is imperative to imbue students with the ability to apply scientific concepts meaningfully, think critically, and make informed decisions regarding real-life contexts [19]. Teachers play a crucial role in this endeavor, serving as facilitators in imparting scientific literacy through various innovative teaching methodologies, with project-based learning (PjBL) standing out as a promising approach [21].

PjBL engages students in long-term, challenging activities wherein they design, execute, and present solutions to real-world problems, fostering a deep understanding of disciplinary concepts and principles [21], [23], [24]. While its implementation demands considerable time and may encounter challenges related to student characteristics, PjBL offers numerous advantages, enhancing student achievement across multiple dimensions and actively involving students in diverse skills such as project management, time management, and problem-solving [27].

Furthermore, PjBL aligns with the objectives of fostering scientific literacy, as evidenced by its effectiveness in enhancing students' scientific questioning, problem-solving abilities, and provision of scientific evidence [21], [22]. Hence, this study aims to explore the impact of project-based learning on students' scientific literacy skills, recognizing its potential to significantly contribute to their educational development and readiness for the challenges of the 21st century.

2 Method

This research utilized a quasi-experimental approach with a two-group pretest-posttest design. Quasi-experimental design involves using at least two groups, where one acts as the experimental group and the other as the control group [28]. The study targeted eighth-grade students from a Junior High School in Medan, encompassing a total of 10 eighth-grade classes. Simple random sampling was employed as the sampling technique. The research sample comprised two classes: VIII-1, serving as the experimental group implementing project-based learning, and VIII-4, serving as the control group employing conventional teaching methods, each comprising 29 students. The research framework is outlined in Table 1.

Table 1. Control Group Pretest-Posttest Research Design

Class	Pretest	Treatment	Posttest
Experimental	O1	X1	O3
Control	O2	X2	O4

Explanation:
X_1: Implementation of Project-Based Learning
X_2: Conventional learning.
O_1:Students' scientific literacy before the implementation of project-based learning.
O_2: Students' scientific literacy before the application of conventional learning.
O_3: Students' scientific literacy after the implementation of project-based learning.
O_4: Students' scientific literacy after the application of conventional learning.

The implementation of Project-based Learning (PjBL) in this study involved several distinct stages aimed at facilitating effective learning. It commenced with the introduction of essential questions to stimulate inquiry and engagement among students. Following this, meticulous planning of the project ensued, ensuring clarity of objectives and tasks. Subsequently, a well-defined schedule for project execution was established, allowing for organized and structured progress. Throughout the process, diligent monitoring of the project's advancement was conducted to address any challenges and maintain momentum. Upon completion, the learning process and project outcomes were rigorously tested to evaluate the efficacy of PjBL in enhancing scientific literacy. The research instrument employed for assessment was a multiple-choice scientific literacy test, encompassing 20 valid items. These items assessed various aspects of scientific literacy, including the explanation of phenomena, evaluation and design of scientific investigations, and interpretation of data and evidence [1].

Data analysis entailed hypothesis testing, employing different methods such as the independent sample t-test to gauge the impact of PjBL on literacy. Additionally, the

N-gain method was utilized to measure the improvement in scientific literacy, contingent upon the normal distribution and homogeneity of data.

The percentage of improvement in scientific literacy skills was analyzed by conducting an average score of normalized gain (N-Gain).

$$\text{N-gain (\%)} = \frac{posttest\ average - pretest\ average}{maximum\ acore - pretest\ average}\ x\ 100 \tag{1}$$

The N-gain values obtained can be categorized into several categories. The N-gain value categories are shown in Table 2 [29].

Table 2. Categories of normalized gain

Gain value (%)	Description
g > 70	High
30 < g = 70	Medium
g = 30	Low

3 Result and Discussion

3.1 Implementation of Project-Based Learning in the Human Excretory System for Students' Junior High School

The first meeting, examining the sub-matter of "Kidney Structure and Function, Disorders and Efforts to Maintain Kidney Health in the Human Excretory System". The first phase of the PjBL model begins with essential questions. Researchers invite students to learn together with news videos of cases of acute kidney failure in children in Indonesia which are currently rampant. Students are interested after observing the video presented. One of the essential questions asked is about the cases of acute kidney failure in children in Indonesia that are currently happening to provoke knowledge, responses, questions that arise from observing the video include, what are the causes of kidney failure? how is it related to the process of urine formation and how can it be prevented?

The second phase is planning the project. The project that will be made in this activity is to make props for urine formation in humans. Researchers divided students into 6 groups consisting of 4-5 students. Researchers also distributed the student worksheets and teaching materials to explore scientific literacy. Students can propose solutions to challenges related to existing problems through planning project designs that will be made [11].

The third phase was to make a schedule for the implementation of the human urine formation props project. Researchers and students collaboratively developed a schedule of activities in completing the project. This phase trains students to be able to work together in preparing a schedule of activities to complete the project.

The fourth phase monitors the progress of the project. The researcher is responsible for monitoring students' activities during the learning activities in completing the project. During this process, students work together to apply what has been designed to be a solution to the problem in the form of a product.

The fifth phase of PjBL is testing the learning process and outcomes. Assessment of the final project results is an activity of analyzing the product of the project that has been carried out by students. At this stage, students discuss the feasibility of the project that has been made along with making a worksheet report.

The sixth phase of PjBL is to evaluate the implementation of project completion. At the end of the learning process, researchers and students reflect on the project activities and results. In this phase, each group presented and explained the project results.

3.2 The Effect of Project Based Learning on Students' Scientific Literacy of Human Excretory System

The recapitulation data of students' scientific literacy in control and experimental classes is presented in Table 3.

Table 3. Recapitulation Data of Students' Scientific Literacy

Category	Data	Class	N	Min Score	Max Score	Mean	Standard Deviation
Scientific Literacy	Pretest	Control	29	5	35	22,50	8,38
		Experiment		15	45	27,24	8,17
	Posttest	Control		40	70	52,83	9,70
		Experiment		65	90	80,67	5,83

N = number of students who took the pretest and posttest

According to the data in Table 3, the range between the highest and lowest scores reveals the disparity in performance between students in the control and experimental groups, followed by calculations of the mean and standard deviation.

This study explores the implementation of project-based learning (PjBL) to enhance students' scientific literacy skills. The outcomes of hypothesis testing indicate a significance level greater than α, where α = 0.05, implying a notable impact of PjBL implementation on students' scientific literacy proficiency concerning the Human Excretory System topic. This finding is corroborated by prior research [21], [30]–[32], which affirms the efficacy of PjBL in advancing students' scientific literacy abilities. The detailed results of hypothesis testing are delineated in Table 4.

Table 4. Hypothesis test of Scientific Literacy Skills

		t-test for Equality of Means	
		t	*Sig. (2-tailed)*
Scientific Literacy	Equal variances assumed	12,771	0,000
	Equal variances not assumed	12,771	0,000

The effectiveness of PjBL in shaping students' scientific literacy abilities is closely tied to the role of each phase within the model. In the initial phase, which starts with posing essential questions, students predominantly develop skills related to understanding and explaining scientific phenomena, as well as interpreting data and evidence scientifically. This phase fosters active student participation in discussing important issues, thus facilitating the cultivation of scientific literacy skills [33].

In the second phase, students engage in project planning, during which their scientific literacy skills are honed through understanding scientific phenomena and crafting scientific investigations for a collaborative project on human urine formation props. Moving on to the third phase, students develop a schedule for implementing the project, leading to improvements in their scientific literacy abilities as they articulate scientific phenomena, assess and design investigations within the implementation timeline, and organize strategies for project completion. This phase also fosters effective collaboration and teamwork among students. In line with the opinion of [33], that PjBL allows students to be given the opportunity to develop scientific literacy skills through the process of student discussion in groups.

In the fourth phase, project progress is monitored, leading to enhancements in students' scientific literacy skills as they deepen their understanding of scientific phenomena while creating products related to kidney failure cases. Moreover, their capacity to evaluate and devise scientific investigations begins to evolve as they address challenges encountered in developing the human urine formation props project and devise solutions. PjBL facilitates idea exchange among students, enabling them to propose solutions to real-life problems through project activities, thereby fostering active and creative collaboration within teams to accomplish project objectives [35]. This is in line with research [36] which explains that PjBL provides greater opportunities for students to think and explore their abilities and can significantly improve students' scientific literacy skills. Students can discover concepts and construct their knowledge through projects that have been given to them [11].

The fifth phase of PjBL is testing the learning process and outcomes. Students' scientific literacy skills are trained during learning activities when discussing in groups, working on worksheets and carrying out project development [30]. PjBL can improve students' scientific literacy by putting theory into practice [37]. Students gain meaningful learning experiences, which can improve scientific literacy through the completion of authentic projects that are directly related to everyday life [38].

In the final phase of PjBL, the evaluation of project completion occurs. This phase contributes to the further development of students' abilities in comprehending and elucidating scientific phenomena, demonstrated through the presentation of findings from the investigation into kidney failure cases via the props project. Students demonstrate their capacity to interpret data and scientific evidence gathered during information gathering activities, effectively presenting them using the props project they have created. Furthermore, students analyze and assess arguments derived from project presentations, drawing suitable scientific conclusions. Through presenting their investigative work, students refine various aspects of scientific literacy competencies [39].

From the second to the fourth sessions, the implementation of the PjBL approach in enhancing scientific literacy skills continued to show progress. PjBL stands out as a valuable method due to its positive impact on enhancing students' scientific literacy abilities [2], [40]. Research findings [41] indicated that employing the PjBL model, particularly through projects such as creating teaching aids, effectively enhances students' scientific literacy skills.

Through PjBL, students can identify and delve into the problem at hand, explore solutions from various sources, and apply their skills and knowledge to resolve it [42]. This sentiment is echoed by [43], who emphasizes the intrinsic link between learning through PjBL and students' scientific literacy development. By engaging with the PjBL learning model, students can refine their critical thinking skills, thereby fostering the development of their scientific literacy.

3.3 Improvement of Students' Scientific Literacy Ability through Project Based Learning

The study's findings revealed that the N-gain percentage increase in students' scientific literacy skills was 73% in the experimental class, categorized as high, while in the control class, it was 39%, falling within the medium category. These findings demonstrate that students' scientific literacy skills exhibit greater improvement when utilizing PjBL compared to conventional learning methods. This aligns with the viewpoints expressed by [24], [30], [44], indicating a notable enhancement in students' scientific literacy skills following the implementation of the project-based learning model. The enhancement of scientific literacy skills is delineated in Table 5.

Table 5. Improvement of Scientific Literacy Ability

Class	N-gain (%)	Category
Control	39	medium
Experiment	73	high

Table 4 illustrates the percentage surge in N-gain for scientific literacy skills post-treatment, with the experimental group exhibiting a higher increase than the control group. The assessment tool for student scientific literacy encompasses three indicators of scientific literacy competency aspects. Table 6 presents the computed percentage increase in scientific literacy skills per indicator across the scientific literacy competency aspects for both the experimental and control classes.

Table 6. Percentage Improvement of N-gain of Scientific Literacy Ability per Indicator

Scientific Literacy Competency Indicators	Experiment Class		N-gain (%)	Category	Control Class		N-gain (%)	Category
	Pretest	Posttest			Pretest	Posttest		
Explaining scientific phenomena	32	84	76	high	25	60	14	low
Evaluate and design scientific investigations	24	84	69	high	22	50	30	medium
Interpret data and evidence scientifically	23	79	72	high	15	55	28	low

In each session, there was a notable enhancement observed in students' scientific literacy skills. Throughout the meetings, the most significant improvement was noted in the ability to explain phenomena scientifically, with a substantial increase of 76%. Following closely was a 72% improvement in interpreting data and evidence scientifically, categorized as high. Additionally, there was a 69% increase in evaluating and designing scientific investigations, falling within the medium category. These improvements were witnessed in the experimental class, where Project-based Learning (PjBL) was implemented. Through PjBL, students were actively involved in exploring formulated problems through project activities, thereby enhancing their scientific literacy skills at each stage of the learning process. PjBL encourages students to engage in investigative tasks, ranging from experiment design to data interpretation and reporting [45].

Contrastingly, the control class saw comparatively lower increases in scientific literacy skills. The N-gain percentage in this class for explaining phenomena scientifically was 14%, categorized as moderate, while for evaluating and designing scientific investigations, it was 28% with a low category. Interpreting data and evidence scientifically saw a 30% increase, also categorized as moderate. The limited growth in scientific literacy skills in the control class can be attributed to the absence of student training in developing these skills during the learning process. This aligns with the viewpoint of [46], which suggests that students' scientific literacy skills remain relatively low when the learning process fails to offer opportunities for understanding daily phenomena. Factors such as teacher influence, learning environment, and administrative support from the school also play crucial roles in shaping students' development of scientific literacy skills [47].

4 Conclusion

It can be concluded that the application of PjBL has an effect on scientific literacy skills on the material of the Human Excretory System in class VIII SMP. There is an improvement in students' scientific literacy skills by using PjBL in the experimental class of 73% with a high category. The findings of this study can influence how learning methods using projects to help students improve their scientific literacy skills. This can be a consideration for teachers in implementing innovative learning methods to optimize interaction, participation, activeness and involvement of participants in scientific and collaborative activities that can affect students' scientific literacy skills.

Limitations of The Present Study and Future Research. The limitation of this study is that finding suitable problems for secondary materials and developing test tools, but there are not many suitable scientific literacy test tools for students. Implementation time is a barrier to conducting research. This is because the students are not yet familiar with the PjBL model made efforts to train scientific literacy take quite a long time from the lesson plan. Some students also lacked focus and attention to reading information. Determining the experiments that can be done is also an obstacle in this study because it must adjust the situation and conditions or the availability of practicum tools at school. Future research should be done to optimize learning time and facilitate a positive learning environment. It is recommended that an activity be carried out at each meeting to increase learning outcomes. Hands-on activities are very useful for exploring scientific literacy skills.

Authors' Contributions. This research contributes to the selection of a suitable science learning model to improve students' scientific literacy skills.

Acknowledgments. The authors are grateful to the Chancellor of Medan State University for the funding assistance provided for this research (Applied Product Research for Fiscal Year 2023) with contract Number 0092/UN33.8/PPKM/PPT/2023.

References

1. R. Rusmansyah, L. Leny, and H. N. Sofia, "Improving Students' Scientific Literacy and Cognitive Learning Outcomes through Ethnoscience-Based PjBL Model," *J. Innov. Educ. Cult. Res.*, vol. 4, no. 1, pp. 1–9, 2023, doi: 10.46843/jiecr.v4i1.382.
2. E. Anggereini, J. Siburian, and A. Hamidah, "Identification of Project Based Learning and STEM PjBL Innovation Based on Socio Scientific Issues as an Effort to Improve Students' Scientific Literacy," *J. Pendidik. Sains Indones.*, vol. 11, no. 1, pp. 165–177, 2023, doi: 10.24815/jpsi.v11i1.26927.
3. R. Bybee, "Program for international student assessment (PISA) 2006 and scientific literacy: A perspective for science education leaders," *Sci. Educ.*, vol. 18, no. 2, pp. 1–13, 2009, [Online]. Available: http://eric.ed.gov/?id=EJ864610%5Cnhttp://files.eric.ed.gov/fulltext/EJ864610.pdf
4. OECD, *PISA 2018 Assessment and Analytical Framework*. 2019. [Online]. Available: https://doi.org/10.1787/b25efab8-en
5. R. L. Bell, L. M. Blair, B. A. Crawford, and N. G. Lederman, "Just do it? Impact of a science apprenticeship program on high school students' understandings of the nature of science and scientific inquiry," *J. Res. Sci. Teach.*, vol. 40, no. 5, pp. 487–509, 2003, doi: 10.1002/tea.10086.
6. K. Becker and K. Park, "Effects of integrative approaches among science , technology , engineering , and mathematics (STEM) subjects on students ' learning : A preliminary meta-analysis," *J. STEM Educ.*, vol. 12, no. 5, pp. 23–38, 2011.
7. Xiufeng and Liu, "Science and the Public. International Journal of Environmental & Science Education," *Int. J. Environ. Sci. Educ.*, vol. 4, no. 3, pp. 301–311, 2009, [Online]. Available: http://www.ijese.com/
8. L. Sholikah and F. N. Pertiwi, "Analysis of Science Literacy Ability of Junior High School Students Based on Programme for International Student Assessement (Pisa)," *INSECTA Integr. Sci. Educ. Teach. Act. J.*, vol. 2, no. 1, pp. 95–104, 2021, doi: 10.21154/insecta.v2i1.2922.
9. L. E. Mason and L. E. Mason, "The Significance of Dewey ' s Democracy and Education for 21st-Century Education The Significance of Dewey ' s Democracy and Education for 21 st -Century Education," vol. 33, no. 1, pp. 41–57, 2021.
10. A. Egan, R. Maguire, L. Christophers, and B. Rooney, "Developing creativity in higher education for 21st century learners: A protocol for a scoping review," *Int. J. Educ. Res.*, vol. 82, pp. 21–27, 2017, doi: 10.1016/j.ijer.2016.12.004.
11. W. Agustina, I. N. S. Degeng, H. Praherdhiono, and S. R. Lestaric, "The Effect of Blended Project-Based Learning for Enhancing Student's Scientific Literacy Skills: An Experimental Study in University," *Pegem Egit. ve Ogr. Derg.*, vol. 13, no. 1, pp. 223–233, 2022, doi: 10.47750/pegegog.13.01.24.
12. OECD, "PISA for Development Assessment and Analytical Framework," *OECD Publ.*, vol. 1, no. 1, pp. 1–198, 2018, [Online]. Available: www.oecd.org/about/publishing/corrigenda.htm.%0Ahttps://doi.org/10.1016/j.tate.2018.03.012%0Ahttps://ejournal.undiksha.ac.id/index.php/KP/article/download/15269/9316%0Ahttps://www.oecd.org/education/pisa-2018-assessment-and-analytical-framework-b25efab8-e

13. I. A. Amala and Y. Yushardi, "Analisis Literasi Sains dan Kemampuan Pemecahan Masalah Siswa SMP pada Materi Zat Aditif dan Zat Adiktif," *J. Pendidik. Mipa*, vol. 12, no. 2, pp. 373–378, 2022, doi: 10.37630/jpm.v12i2.610.
14. I. W. Merta, I. P. Artayasa, K. Kusmiyati, N. Lestari, and D. Setiadi, "Profil Literasi Sains dan Model Pembelajaran dapat Meningkatkan Kemampuan Literasi Sains," *J. Pijar Mipa*, vol. 15, no. 3, pp. 223–228, 2020, doi: 10.29303/jpm.v15i3.1889.
15. F. Zulaiha and D. Kusuma, "Analisis Kemampuan Literasi Sains Peserta didik SMP di Kota Cirebon," *J. Pendidik. Fis. dan Teknol.*, vol. 7, no. 2, pp. 190–201, 2021, doi: 10.29303/jpft.v7i2.3049.
16. J. Afriana *et al.*, "Analysis of Scientific Literacy Ability Junior High School Students in Science Learning on Environmental Pollution," *Pros. Semin. Nas. Kim. UNY*, vol. 9, no. 2, pp. 261–267, 2017, doi: 10.29303/jpm.v15i3.1889.
17. A. H. Odja and C. S. Payu, "Analisis Kemampuan Awal Literasi Sains Siswa Pada Konsep IPA," in *Prosiding Seminar Nasional Kimia Jurusan Kimia FMIPA Universitas Negeri Surabaya*, 2014, vol. 1, no. 1, pp. 40–47. doi: 10.33086/ehdj.v1i1.291.
18. S. Thomson, K. Hillman, and L. De Bortoli, *Programme for International Student Assessment: A Teacher 's Guide to PISA Scientific Literacy*. 2013.
19. S. Rahayu, "Mengoptimalkan Aspek Literasi Pembelajaran Kimia Abad 21," *Pros. Semin. Nas. Kim. UNY*, vol. 21, pp. 1–4, 2017.
20. R. A. Z. El Islami and P. Nuangchalerm, "Comparative Study of Scientific literacy: Indonesian and Thai pre-service Science Teachers Report," *Int. J. Eval. Res. Educ.*, vol. 9, no. 2, pp. 261–268, 2020, doi: 10.11591/ijere.v9i2.20355.
21. I. Wardah, K. Septaria, K. Mahbubah, and H. Mubarok, "The Effect of Project Based Learning (PjBL) Model on Students' Science Literacy in Social Studies Subjects," *Jurnal Penelitian dan Pengkajian Ilmu Pendidikan: e-Saintika*, vol. 6, no. 2. pp. 108–119, 2022. doi: 10.36312/esaintika.v6i2.738.
22. A. Roosyanti, "the Effect of Project-Based Learning Towards Science Literation of Elementary School Students," *J. Pena Sains*, vol. 7, no. 2, pp. 54–59, 2020, doi: 10.21107/jps.v7i2.6866.
23. F. Movahedzadeh, R. Patwell, J. E. Rieker, and T. Gonzalez, "Project-Based Learning to Promote Effective Learning in Biotechnology Courses," *Educ. Res. Int.*, vol. 2012, pp. 1–8, 2012, doi: 10.1155/2012/536024.
24. E. W. Winarni and E. P. Purwandari, "Project-based learning to improve scientific literacy for primary education postgraduate students in science subject," *J. Prima Edukasia*, vol. 8, no. 1, pp. 67–77, 2020, doi: 10.21831/jpe.v8i1.30618.
25. K. Kusuma and J. Artama, "Promoting the 21 st Century Skills Using Project-Based Learning," *Lang. Circ. J. Lang. Lit.*, vol. 17, no. 2, pp. 1–9, 2023.
26. I. Kusumawati, "The Implementation of Project- Based Learning ' s Speakin g Skill for Tenth Grade Vocational High School Students The Implementation of Project-Based Learning ' s Speaking Skill for Tenth Grade Vocational High School Students," vol. 19, no. 2, pp. 2–6, 2019.
27. I. W. U. Tias and S. Octaviani, "the Effect of Using the Project Based Learning Model on Process Skills and Science Literation Skills," *Jhss (Journal Humanit. Soc. Stud.*, vol. 2, no. 2, pp. 25–30, 2018, doi: 10.33751/jhss.v2i2.905.
28. Rukminingsih, G. Adnan, and M. A. Latief, *Metode Penelitian Pendidikan. Penelitian Kuantitatif, Penelitian Kualitatif, Penelitian Tindakan Kelas*, vol. 53, no. 9. 2020.
29. D. E. Meltzer, "The relationship between mathematics preparation and conceptual learning gains in physics: A possible 'hidden variable' in diagnostic pretest scores," *Am. J. Phys.*, vol. 70, no. 12, pp. 1259–1268, 2002, doi: 10.1119/1.1514215.
30. D. A. Fauziah, E. Erman, Enny Susiyawati, and Mohammad Budiyanto, "Implementation of Project-Based Learning Models to Improve Science Literacy of Junior High School Students," *J. Pijar Mipa*, vol. 18, no. 2, pp. 176–182, 2023, doi: 10.29303/jpm.v18i2.4795.

31. Kamariah, Muhlis, and A. Ramdani, “Pengaruh Penggunaan Model Pembelajaran Project Based Learning (PJBL) Terhadap Literasi Sains Peserta Didik,” *J. Classr. Action Res.*, vol. 5, no. 1, pp. 210–215, 2023, doi: 10.29303/jcar.v5i1.2925.
32. R. S. Nita and Irwandi, “Peningkatan Keterampilan Berpikir Kreatif Siswa Melalui Model Project Based Learning (PjBL),” *BIOEDUSAINS J. Pendidik. Biol. dan Sains*, vol. 4, no. 2, pp. 231–238, 2021, [Online]. Available: http://journal.unilak.ac.id/index.php/JIEB/article/view/3845%0Ahttp://dspace.uc.ac.id/handle/123456789/1288
33. N. Nuraini, I. H. Asri, and N. Fajri, “Development of Project Based Learning with STEAM Approach Model Integrated Science Literacy in Improving Student Learning Outcomes,” *J. Penelit. Pendidik. IPA*, vol. 9, no. 4, pp. 1632–1640, 2023, doi: 10.29303/jppipa.v9i4.2987.
34. R. Simbolon and H. D. Koeswanti, “Comparison of (Project Based Learning) Models with Pbl (Problem Based Learning) Models to Determine Student Learning Outcomes and Motivation,” *Int. J. Elem. Educ.*, vol. 4, no. 4, pp. 519–529, 2020, [Online]. Available: https://ejournal.undiksha.ac.id/index.php/IJEE
35. N. L. P. N. S. P. Astawa, L. P. Artini, and P. K. Nitiasih, “Project-based learning activities and efl students’ productive skills in english,” *J. Lang. Teach. Res.*, vol. 8, no. 6, pp. 1147–1155, 2017, doi: 10.17507/jltr.0806.16.
36. K. Chrysti Suryandari, Sajidan, S. Budi Rahardjo, Z. Kun Prasetyo, and S. Fatimah, “Project-based science learning and pre-service teachers’ science literacy skill and creative thinking,” *Cakrawala Pendidik.*, vol. 37, no. 3, pp. 345–355, 2018, doi: 10.21831/cp.v38i3.17229.
37. E. S. Sugianto, “The Role of Collaborative Learning and Project Based Learning to Increase Students’ Cognitive Levels in Science Literacy,” *Proceedings of the International Conference on Madrasah Reform 2021 (ICMR 2021)*, vol. 633. 2022. doi: 10.2991/assehr.k.220104.011.
38. A. Sholahuddin, Y. Artaulyna, P. Saadi, and Syahmani, “Students’ Scientific Literacy as the Effect of Project-Based Learning Using a Simple Colloid Product,” *AIP Conf. Proc.*, vol. 2600, no. December, 2022, doi: 10.1063/5.0112512.
39. F. Alatas and L. Fauziah, “Model problem based learning untuk meningkatkan kemampuan literasi sains pada konsep pemanasan global,” *JIPVA (Jurnal Pendidik. IPA Veteran)*, vol. 4, no. 2, p. 102, 2020, doi: 10.31331/jipva.v4i2.862.
40. S. Maghfirah, M. Syukri, A. Halim, and N. M. Arsad, “PjBL-STEM to Improve Students ’ Scientific Literacy Skills,” *J. Teknol. Pendidik.*, vol. 11, no. 1, pp. 1–17, 2023.
41. R. Munawaroh, A. Rusilowati, and Fianti, “Improving Scientific Literacy and Creativity through Project Based Learning,” *Phys. Commun.*, vol. 2, no. 2, pp. 85–93, 2018, [Online]. Available: http://journal.unnes.ac.id/nju/index.php/pc
42. Y. Yamin, A. Permanasari, S. Redjeki, and W. Sopandi, “Implementing Project-Based Learning to Enhance Creative Thinking Skills on Water Pollution Topic,” *JPBI (Jurnal Pendidik. Biol. Indones.*, vol. 6, no. 2, pp. 225–232, 2020, doi: 10.22219/jpbi.v6i2.12202.
43. L. O. Fitriyani and W. Anggraini, “Project based Learning: Pengaruhnya terhadap keterampilan proses sains peserta didik di Tanggamus,” vol. 01, no. November, pp. 243–253, 2018.
44. Muhibbuddin, N. Yustina, and Safrida, “Implementation of Project-Based Learning (PjBL) Model in Growth and Development Learning to Increase the Students’ Science Literacy and Critical Thinking Skills,” *IJAEDU- Int. E-Journal Adv. Educ.*, vol. 6, no. 16, pp. 66–72, 2020, doi: 10.18768/ijaedu.616008.
45. G. N. Utami and Senam, “Implementation of Project Based Learning Model for Enhancing Students ’ Practical Skill and Scientific Literacy,” *J. Pendidik. dan Pembelajaran Kim.*, vol. 10, no. 2, pp. 103–112, 2021, doi: 10.23960/jppk.v10.i2.2021.08.

46. N. K. Muliastrini, D. Nyoman, and D. Gede Rasben, “Pengaruh Model Pembelajaran Inkuiri dengan Teknik Scaffolding Terhadap Kemampuan Literasi Sains dan Prestasi Belajar IPA,” *J. Ilm. Sekol. Dasar*, vol. 3, no. 3, p. 254, 2019, doi: 10.23887/jisd.v3i3.14116.
47. K. M. E. Palines and R. A. O. Dela Cruz, “Facilitating Factors of Scientific Literacy Skills Development Among Junior High School Students,” *Lumat Int. J. Math, Sci. Technol. Educ.*, vol. 9, no. 1, pp. 546–569, 2021, doi: 10.31129/LUMAT.9.1.1520.