Jurnal Pendidikan Fisika
Vol. 14 No. 2, Desember 2025_260-268
DOI: 10.24114/jpf.v14i2.70562
p-ISSN: 2552-732X
e-ISSN: 2301-7651

Research Article

OPEN ACCESS

Enhancing Students' Scientific Literacy Ability Through Phenomenon-Based Experiential Learning With Formative Assessment

[1]Hidayat Pradananta, [1]Lia Yuliati*, [1]Arif Hidayat

[1] Department of Physics Education, Faculty of Mathematics and Natural Science, Universitas Negeri Malang, Malang, Jawa Timur 65145, Indonesia

INFO ARTIKEL

Article History:
Submitted: 21-10-2025
Revised : 18-11-2025
Accepted : 27-12-2025
Published: 31-12-2025

Keywords:
Scientific Literacy;
Phenomenon Based Experiential Learning;
Formative Assessment;
Static Fluid

Kata Kunci:
Literasi Sains;
Phenomenon Based Experiential Learning;
Formative Assessment;
Fluida Statis

ABSTRACT

This study aims to analyze the effect of Phenomenon-Based Experiential Learning integrated with Formative Assessment on improving students' scientific literacy in the topic of static fluids. The research employed a quasi-experimental method with a control group Pre-test–Post-test design, involving 71 eleventh-grade students from one of the Islamic Senior High Schools (MAN) in Padangsidimpuan, Indonesia. The experimental class received instruction using the Phenomenon-Based Experiential Learning model accompanied by Formative Assessment, while the control class was taught through conventional learning. Data were collected using eight essay questions covering the topics of hydrostatic pressure, Pascal's law, and Archimedes' principle. The findings revealed a significant difference between the two classes, with an N-gain score of 0.66 (medium category) in the experimental class and 0.29 (low category) in the control class. The analysis of each scientific literacy indicator also showed that the Explain Phenomena Scientifically (EPS) and Interpret Data and Evidence Scientifically (IDES) indicators achieved high improvement categories, while the Evaluate and Design Scientific Enquiry (EDSE) indicator increased within the medium category. These results indicate that Phenomenon-Based Experiential Learning integrated with Formative Assessment is effective in enhancing students' scientific literacy skills.

ABSTRAK

Penelitian ini bertujuan untuk menganalisis pengaruh *Phenomenon-Based Experiential Learning* disertai *Formative Assessment* terhadap peningkatan kemampuan literasi sains siswa pada materi fluida statis. Penelitian menggunakan metode kuasi-eksperimen dengan desain *control group pre-test–post-test* yang melibatkan 71 siswa kelas XI dari salah satu MAN di Kota Padangsidimpuan, Indonesia. Kelas eksperimen mendapatkan pembelajaran dengan model *Phenomenon-Based Experiential Learning* disertai *Formative Assessment*, sedangkan kelas kontrol mengikuti pembelajaran konvensional. Data dikumpulkan melalui delapan soal esai yang mencakup topik tekanan hidrostatis, hukum Pascal, dan hukum Archimedes. Hasil penelitian menunjukkan adanya perbedaan signifikan antara kedua kelas, dengan nilai N-gain sebesar 0,66 (kategori sedang) pada kelas eksperimen dan 0,29 (kategori rendah) pada kelas kontrol. Analisis setiap indikator literasi sains juga memperlihatkan bahwa indikator *Explain Phenomena Scientifically* (EPS) dan *Interpret Data and Evidence Scientifically* (IDES) mengalami peningkatan dalam kategori tinggi, sementara *Evaluate and Design Scientific Enquiry* (EDSE) meningkat pada kategori sedang. Temuan ini mengindikasikan bahwa *Phenomenon-Based Experiential Learning* disertai *Formative Assessment* efektif dalam meningkatkan literasi sains siswa.

*Corresponding Author
E-mail Adress: hidayat.pradananta.2303218@students.um.ac.id

INTRODUCTION

The 21st century is characterized by rapid advancements in science and technology that have had a significant impact on various aspects of life. In the context of education, this development requires students to master 21st-century skills, such as critical thinking and problem-solving abilities, in order to adapt to the challenges of the times. (Soh dkk., 2010). One of the essential fields that supports the development of these skills is science education, as through science learning, students are encouraged to apply scientific concepts to solve real-world problems in everyday life. (Arifin & Sunarti, 2017a; Deta dkk., 2024). In line with this urgency, improving the quality of science education has now become a global priority, which is realized, among others, through the strengthening of scientific competence by emphasizing the importance of scientific literacy as a foundation for understanding, evaluating, and applying scientific knowledge responsibly. (Bossér, 2024; Howell & Brossard, 2021; Osborne & Allchin, 2024).

Literacy, in its general sense, refers to the ability to use various skills to actively participate in society. Meanwhile, scientific literacy (SL) refers to scientific competence that encompasses logical reasoning, creative thinking, and problem-solving abilities. (Kutlu-Abu dkk., 2024; Sjöström dkk., 2017; Vrana, 2019). Scientific literacy also reflects an individual's capacity to understand and engage with science- and technology-based issues that arise in everyday life. This competence includes the skills to explain phenomena scientifically, evaluate and design scientific enquiry, and interpret data and evidence scientifically. (OECD, 2023). In addition, understanding natural phenomena and the processes through which scientific facts are established constitutes an essential component of this literacy. (Raymo, 1998), including an understanding of the nature of science and its role in constructing scientific arguments (Yuenyong, 2013). In an increasingly diverse and multicultural society, opportunities for learning have become more widely accessible. (Mappaenre dkk., 2023).

Technological developments and the currents of globalization have transformed the way we perceive science—not merely as a collection of knowledge, but as a process of understanding the interrelationships between humans, nature, and technology (Skare & Soriano, 2021). Therefore, many countries have made scientific literacy a primary goal of their education systems (Luzyawati dkk., 2025), as the development of a scientific attitude fosters improvements in problem-solving abilities and academic achievement (Annisa dkk., 2023)

In Indonesia, scientific literacy has gained attention since the 2006 Curriculum, was further strengthened in the 2013 Curriculum through the implementation of an inquiry-based approach and student-centered learning (Aidoo, 2023; Luzyawati dkk., 2025), and continues to be developed in the *Merdeka Curriculum* through the application of project-based and problem-solving learning (Suharyat dkk., 2023). Unfortunately, the idealization of scientific literacy has not yet been fully reflected in the actual abilities of Indonesian students..

The scientific literacy skills possessed by each student play a crucial role in helping them address global issues, make informed decisions, and gain a deeper understanding of natural and social phenomena (Kamila dkk., 2024). However, data from the 2022 Programme for International Student Assessment (PISA) released by the OECD indicate that Indonesian students' scientific literacy remains low, with an average score of 383, ranking 71st out of 81 participating countries—well below the international average (OECD, 2023). This low achievement is attributed to limited conceptual understanding resulting from instructional approaches that emphasize memorization rather than meaningful learning (Jufri dkk., 2016). In addition, teachers' limited ability to connect science learning with real-world phenomena in students' surroundings has also hindered the development of scientific literacy (Arifin & Sunarti, 2017b; Treacy & Kosinski-Collins, 2011). One instructional approach aligned with these principles is *phenomenon-based learning.*

Phenomenon-based learning is effective in enhancing scientific literacy as it enables the presentation of concepts from multiple perspectives (Santhalia & Yuliati, 2021; Symeonidis & Schwarz, 2016). The use of multiple representations of physical phenomena helps students in problem-solving, thereby improving conceptual understanding and learning outcomes (McPadden & Brewe, 2017). A learning model that emphasizes direct student experience is known as *experiential learning* (A. Y. Kolb & Kolb, 2009; D. A. Kolb, 2014a; Roberts, 2018), which has been extensively studied in educational contexts (A. Y. Kolb & Kolb, 2005). Several studies have shown that experiential learning not only better prepares students to face real-world challenges (Roberts, 2018), but also reduces cognitive load (Abdulwahed & Nagy, 2009; Riskawati dkk., 2020) and enhances critical thinking skills (Mabie & Baker, 1996; Mertayasa dkk., 2024). Other research findings also indicate that the implementation of experiential learning has a positive effect on students' academic achievement (Nisra dkk., 2025). During the learning process, teachers should also engage students as active learning resources for one another through collaborative activities, provide feedback, and encourage self-assessment; this interactive process between teachers and students is referred to as *formative assessment* (Box dkk., 2019; Kusairi dkk., 2021). Conceptual understanding can be developed through direct experience, where students require prior knowledge to comprehend a concept through observation of real phenomena, and active teacher–student interaction can enhance students' learning achievement (McManus, 2008; Symeonidis & Schwarz, 2016). However, the implementation of *phenomenon-based experiential learning* integrated with *formative assessment* remains relatively rare.

Based on various theoretical studies, *phenomenon-based experiential learning* has been proven effective in enhancing students' scientific literacy. This learning approach is also aligned with the characteristics of static fluid topics, which emphasize understanding through the observation of real-world phenomena and active interaction between teachers and students. Therefore, this study focuses on the implementation of *phenomenon-based experiential learning* integrated with *formative assessment* in exploring the concept of static fluids, with the aim of determining its effect on students' scientific literacy.

METHODS

This research is a quantitative study employing a quasi-experimental approach with a *control group pre-test–post-test* design, as illustrated in Figure 1.

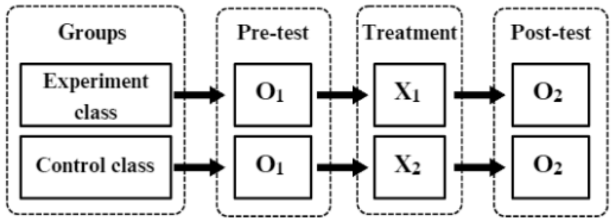

Figure 1. Research Method

Description :

O1 : Pre-test before treatment

O2 : Post-test after treatment

X1 :Treatment with Phenomenon Based Experiential Learning

X2 : Treatment with conventional learning

Two groups were involved in this study, namely the experimental group and the control group, each receiving different treatments. Both groups first took a Pre-test to measure their scientific literacy skills. Subsequently, the experimental group participated in learning activities using the *phenomenon-based experiential learning* model, while the control group received conventional instruction. After the learning process was completed, a post-test was administered to assess the improvement in scientific literacy for each group. A total of 71 eleventh-grade students (Phase F) participated in this study. All participants were drawn from one Islamic Senior High School (MAN) in Padangsidimpuan, North Sumatra, and were selected randomly using a cluster sampling technique. Of these, 36 students were assigned to the control group and 35 students to the experimental group.

The data used in this study were quantitative, obtained from the results of pre-tests and post-test that reflected students' scientific literacy skills before and after receiving different treatments. The measurement instrument consisted of eight essay questions covering the topic of static fluids, including hydrostatic pressure, Pascal's law, and Archimedes' principle. The instrument underwent construct validity testing by experts and was deemed suitable for use. In addition, empirical validation was conducted on the scientific literacy test administered to 105 twelfth-grade students from MAN schools in Padangsidimpuan who had previously studied the topic of static fluids in the prior semester. The analysis results indicated that all eight questions met the validity criteria, with a high level of reliability as indicated by a Cronbach's alpha coefficient of 0.854. The detailed distribution of the items based on static fluid topics and scientific literacy indicators is presented in Table 1.

Table 1. The Items Distribution of the Scientific Literacy Ability Test Instrument

Indicator	Issue		
	I	II	III
Explain phenomena scientifically	(1), (5)	(7)	
Evaluate and design scientific enquiry		(8)	(3), (4)
Interpret data and evidence scientifically	(2), (6)		

Note :
Issue I : Hydrostatic Pressure
Issue II : Pascal's Law
Issue III : Archimedes' Principle

The data analysis in this study employed parametric statistical methods, as the data were normally distributed and homogeneous. An independent sample t-test was conducted to determine whether there was a significant difference in scientific literacy skills between students in the experimental and control classes, while the improvement in each group's scientific literacy was measured using the N-Gain score (Hake, 1998).

Table 2. The Category of Hake's N-Gain

N-gain score	Category
$g>0.7$	High
$0.3\leq g<0.7$	Medium
$g<0.3$	Low

Table 2 presents the N-Gain categories (Hake, 1998) based on the data of students' scientific literacy improvement.

RESULT AND DISCUSSION

The hypothesis testing was conducted after performing the prerequisite tests, namely the normality test and the homogeneity test. The normality test was used to evaluate whether the data were normally distributed or not. If the data were not normally distributed, a non-parametric test would be applied. Meanwhile, the homogeneity test was carried out to assess whether the variances of the compared groups were equal. By conducting these prerequisite tests, the results of the hypothesis testing became more accurate and reliable.

Table 3 presents the results of the normality and homogeneity tests for the Pre-test and Post-test data from both classes.

Table 3. Prerequisite Tests for Pre-test and Post-test Data

Class	df	Sig.normality test	Sig. homogeneity test
Control Pre-test	36	0.275	0.887
Control Post-test	36	0.605	
Experimental Pre-test	35	0.666	0.519
Experimental Post-test	35	0.056	

Based on the normality test using the Shapiro–Wilk method, it was found that the data from both the experimental and control groups were normally distributed ($p > 0.05$). Meanwhile, the results of Levene's test, which was used to examine homogeneity, indicated that the variances of the two classes were homogeneous. These findings confirm that the samples used in this study met the assumptions required for parametric testing

The results of the independent t-test for the Pre-test scores are presented in Table 4.

Table 4. Independent t test for Pre-test Scores

Class	Average	Sig	Conclusion
Control	5.81	0.092	Not Significant
Ekperiment	4.86		

Table 4 shows the results of the independent t-test on the equality of students' scientific literacy in the Pre-test scores, which yielded a significance value (2-tailed) of 0.092. Since $p > 0.05$, it can be concluded that the initial scientific literacy abilities of students in both classes were at the same level. Therefore, the differences in scientific literacy outcomes observed at the end of the learning process can be attributed solely to the different treatments applied to each class.

The independent t-test used to examine the differences in scientific literacy abilities based on the Post-test scores is presented in Table 5.

Table 5. Independent t-test for Post-test Scores

Class	Average	Sig	Conclusion
Control	16.64	0.000	Significant Difference
Ekperiment	19.54		

Table 5 shows a significant difference between the two classes, with a significance value of 0.000. This result indicates that the scientific literacy abilities of students in the experimental and control classes were not the same. The difference was influenced by the learning model implemented in the experimental class, which applied *Phenomenon-Based Experiential Learning* with formative assessment, while the control class follows conventional teaching which only learns through full lectures from the teacher. This difference in instructional approach had a significant positive effect on students' scientific literacy.

The results of the study indicate that the implementation of *Phenomenon-Based Experiential Learning* combined with formative assessment has a significant positive effect on students' scientific literacy skills. This model integrates four stages of experiential learning: *concrete experience*, *reflective observation*, *abstract conceptualization*, and *active experimentation* (Santhalia & Yuliati, 2021). In the *concrete experience* stage, students directly observe physical phenomena occurring around them, making the learning experience more relevant and contextual. The next stage, *reflective observation*, encourages students to consciously reflect on their experiences and begin constructing meaning from their observations. Subsequently, during *abstract conceptualization*, students formulate physics concepts or principles based on their reflections, and in the final stage, *active experimentation*, they design strategies or solutions to problems using the concepts they have developed (Santhalia dkk., 2020; Santhalia & Yuliati, 2021). Through these stages, the learning process in physics—particularly on the topic of static fluids, which is closely related to real-world phenomena and students' everyday experiences—becomes more connected and tangible. This finding is consistent with previous research, which demonstrated that *Phenomenon-Based Experiential Learning* can enhance students' scientific literacy (Santhalia & Yuliati, 2021), problem-solving skills (Santhalia dkk., 2020), and conceptual understanding of physics (Chinaka, 2021; Yuliati & Mufti, 2020).

When this learning process is integrated with formative assessment, it becomes more meaningful because students are not only evaluated based on final outcomes but are also encouraged to actively engage in continuous scientific thinking. Formative assessment provides feedback that enables students to monitor the development of their understanding and helps teachers adjust instructional approaches to meet students' needs (Black & Wiliam, 2009). Consequently, the learning process becomes more dynamic, reflective, and personalized. Formative assessment has been proven to offer dual benefits in the learning process. For teachers, it not only supports the development of their professional skills (James, 2017), but also facilitates quick access to feedback (Bennett, 2011; Kusairi dkk., 2021). Real-time feedback allows teachers to promptly identify students' learning difficulties and adjust their teaching strategies for greater effectiveness if (Elmahdi dkk., 2018). On the other hand, students receive timely support, enabling them to develop a deeper understanding of scientific concepts. Furthermore, the integration of formative assessment into the learning process has been shown to significantly enhance students' conceptual understanding (Decristan dkk., 2015).

There are several factors contributing to students' low level of scientific literacy, one of which is their initial ability. Students with strong prior knowledge generally find it easier to understand new concepts, whereas those with weaker initial abilities tend to face difficulties in the learning process. Prior knowledge serves as a foundation that helps students construct new understanding by connecting it with concepts already stored in long-term memory (Santhalia dkk., 2020). Learning that involves direct experience allows students to develop cognitive, psychomotor, and affective abilities in an integrated manner (D. A. Kolb, 2014b). Therefore, the implementation of *phenomenon-based experiential learning* with *formative assessment* has been shown to have a positive effect on students' scientific literacy, as it provides opportunities for them to learn through real experiences and connect physics concepts—particularly those related to static fluids—with everyday phenomena.

The improvement in students' scientific literacy skills can be more clearly seen from the results of the N-Gain analysis presented in Table 6. These findings illustrate the extent to which students' scientific literacy skills improved after participating in the learning process..

Table 6. N-gain Score

Parameter	Class	
	Experiment	Control
N-gain	0.66	0.29
Category	Medium	Low

Table 6 shows that the N-Gain values for each class were 0.66 for the experimental class and 0.29 for the control class. The experimental class falls into the medium category, while the control class is in the low category. These results indicate that *phenomenon-based experiential learning* combined with *formative assessment* led to a significantly greater improvement in scientific literacy compared to conventional learning. This pattern of improvement is also consistent with the results of the independent t-test discussed earlier. Furthermore, the N-Gain value for the control class was well below the average threshold for the effectiveness of active learning, which is 0.48 (Jackson et al., 2008). whereas the experimental class successfully exceeded this benchmark.

To determine which aspects showed improvement, an N-Gain analysis was conducted for each indicator, as presented in Figure 2.

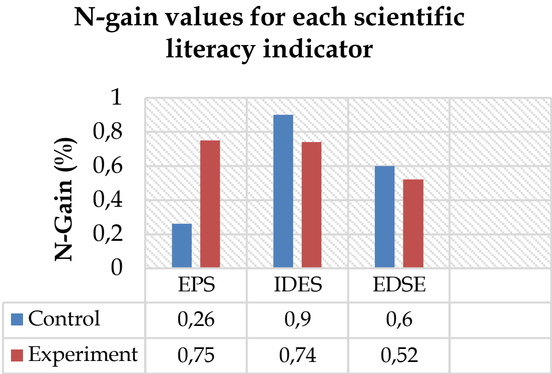

Figure 2. N-gain Values for Each Scientific Literacy Indicator

An interesting pattern can be observed in Figure 2. Although all scientific literacy indicators showed improvement in the experimental class, the EDSE (Evaluate and Design Scientific Enquiry) indicator increased within the medium category (0.52), while the EPS (Explain Phenomena Scientifically) and IDES (Interpret Data and Evidence Scientifically) indicators reached the high category, with N-Gain scores of 0.75 and 0.74, respectively. The EDSE competency requires students to demonstrate skills in assessing the quality of data, based on the understanding that data are not always entirely accurate. In addition, it demands the ability to determine whether an investigation is grounded in a specific theoretical framework or aimed at identifying patterns within the obtained data. (OECD, 2015). However, some students were still unable to fully demonstrate these competencies, particularly in evaluating data accuracy and understanding the relationship between theoretical concepts and the results of their investigations on static fluid topics. This can be seen in learning Archimedes' principle, when several students still experience errors in evaluating experimental data related to the phenomenon of floating and levitating objects, so that the relationship between observation results and theoretical basis is not yet understood properly. .Nevertheless, overall, these findings reinforce the evidence that *phenomenon-based experiential learning* combined with *formative assessment* is more effective in enhancing students' scientific literacy competencies across all indicators.

CONCLUSION

The results of the study revealed a significant difference in scientific literacy skills between the experimental and control classes. The experimental class, which implemented *Phenomenon-Based Experiential Learning with Formative Assessment*, demonstrated a higher improvement in scientific literacy compared to the control class that received conventional instruction. The average Post-test score of students in the experimental class was considerably higher, with an improvement level categorized as medium, whereas the control class achieved only a low level of improvement. These findings indicate that learning based on real-world experiences, complemented by formative assessment, is more effective in enhancing students' scientific literacy than conventional teaching methods.

REFERENCES

Abdulwahed, M., & Nagy, Z. K. (2009). Applying Kolb's experiential learning cycle for laboratory education. *Journal of Engineering Education*, *98*(3), 283–294.

Annisa, R., Asrizal, A., & Werina, W. (2023). Application of physics e-learning material integrated social-scientific issue context to improve students' scientific literacy skills. *Journal of Innovative Physics Teaching*, *1*(1), 29–39.

Arifin, L., & Sunarti, T. (2017a). The Improvement of Students Scientific Literacy Through Guided Inquiry Learning Model on Fluid Dynamics Topic. *Jurnal Penelitian Fisika Dan Aplikasinya (JPFA)*, *7*(2), 68–78.

Arifin, L., & Sunarti, T. (2017b). The Improvement of Students Scientific Literacy Through Guided Inquiry Learning Model on Fluid Dynamics Topic. *Jurnal Penelitian Fisika Dan Aplikasinya (JPFA)*, *7*(2), 68–78.

Bennett, R. E. (2011). Formative assessment: A critical review. *Assessment in Education: Principles, Policy & Practice*, *18*(1), 5–25.

Black, P., & Wiliam, D. (2009). Developing the theory of formative assessment. *Educational Assessment, Evaluation and Accountability (Formerly: Journal of Personnel Evaluation in Education)*, *21*, 5–31.

Bossér, U. (2024). Transformation of school science practices to promote functional scientific literacy. *Research in Science Education*, *54*(2), 265–281.

Box, C., Box, & Vernikova. (2019). *Formative assessment in United States classrooms*. Springer.

Chinaka, T. W. (2021). The effect of PhET simulation vs. Phenomenon-based experiential learning on students' integration of motion along two independent axes in projectile motion. *African Journal of Research in Mathematics, Science and Technology Education*, *25*(2), 185–196.

Decristan, J., Klieme, E., Kunter, M., Hochweber, J., Büttner, G., Fauth, B., Hondrich, A. L., Rieser, S., Hertel, S., & Hardy, I. (2015). Embedded formative assessment and classroom process quality: How do they interact in promoting science understanding? *American Educational Research Journal*, *52*(6), 1133–1159.

Deta, U. A., Ayun, S. K., Laila, L., Prahani, B. K., & Suprapto, N. (2024). PISA science framework 2018 vs 2025 and its impact in physics education: Literature review. *Momentum: Physics Education Journal*, *8*(1), 95–107.

Elmahdi, I., Al-Hattami, A., & Fawzi, H. (2018). Using Technology for Formative Assessment to Improve Students' Learning. *Turkish Online Journal of Educational Technology-TOJET*, *17*(2), 182–188.

Framework, O. P. (2015). *PISA 2015 assessment and analytical framework: Science, reading, mathematic, financial literacy and collaborative problem solving*.

Hake, R. R. (1998). Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics*, *66*(1), 64–74.

Howell, E. L., & Brossard, D. (2021). (Mis) informed about what? What it means to be a science-literate citizen in a digital world. *Proceedings of the National Academy of Sciences*, *118*(15), e1912436117.

James, M. (2017). Embedding formative assessment in classroom practice. *Life in Schools and Classrooms: Past, Present and Future*, 509–525.

Jufri, A. W., Setiadi, S., & Sripatmi, D. (2016). Scientific reasoning ability of prospective student teacher in the excellence program of mathematics and science teacher education in University of Mataram. *Jurnal Pendidikan IPA Indonesia*, *5*(1), 69–74.

Kamila, K., Wilujeng, I., Jumadi, J., & Ungirwalu, S. Y. (2024). Analysis of Integrating Local Potential in Science Learning and its Effect on 21st Century Skills and Student Cultural Awareness: Literature Review. *Jurnal Penelitian Pendidikan IPA*, *10*(5), 223–233.

Kolb, A. Y., & Kolb, D. A. (2005). Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education*, *4*(2), 193–212.

Kolb, A. Y., & Kolb, D. A. (2009). Experiential learning theory: A dynamic, holistic approach to management learning, education and development. *The SAGE Handbook of Management Learning, Education and Development*, *7*(2), 42–68.

Kolb, D. A. (2014a). *Experiential learning: Experience as the source of learning and development*. FT press.

Kolb, D. A. (2014b). *Experiential learning: Experience as the source of learning and development*. FT press.

Kusairi, S., Wahyuni, D. R., & Ali, M. (2021). The effect of the STEM approach with the formative assessment in PBL on students' problem solving skills on fluid static topic. *Journal of Physics: Conference Series*, *2098*(1), 012025.

Kutlu-Abu, N., Bozgün, K., & Uluçinar-Sağir, Ş. (2024). Studies on scientific literacy in primary education: A bibliometric and content analyses. *Hungarian Educational Research Journal*, *14*(2), 158–183.

Luzyawati, L., Hamidah, I., Fauzan, A., & Husamah, H. (2025). Higher-order thinking skills-based science literacy questions for high school students. *Journal of Education and Learning (EduLearn)*, *19*(1), 134–142.

Mabie, R., & Baker, M. (1996). A comparison of experiential insturctional strategies upon the science process skills of urban elementary students. *Journal of Agricultural Education*, *37*(2), 1–7.

Mappaenre, A., Ruswandi, U., Erihadiana, M., Nuraini, Y., & Wiwaha, R. S. (2023). Multicultural education in Indonesia: Characteristics and urgency. *JISIP (Jurnal Ilmu Sosial Dan Pendidikan)*, *7*(2), 874–876.

McManus, S. (2008). *Attributes of effective formative assessment*. Washington, DC: Council of Chief State School Officers.

McPadden, D., & Brewe, E. (2017). Impact of the second semester University Modeling Instruction course on students' representation choices. *Physical Review Physics Education Research*, *13*(2), 020129.

Mertayasa, I. K., Sumarni, N., & Indraningsih, K. A. (2024). A Literature Review: The Impact of Experiential Learning on Developing Students' Critical Thinking Skills in Indonesia. *International Journal of Current Educational Studies*, *3*(1).

Nisra, N., Saehana, S., Paramita, I., Untara, K. A. A., & Ratnaningtyas, D. I. (2025). Perbedaan Hasil Belajar Fisika Materi Usaha Dan Energi Melalui Experiential Learning Berbasis Video dengan Pembelajaran Konvensional. *JPFT (Jurnal Pendidikan Fisika Tadulako Online)*, *13*(1), 17–23.

OECD. (2023). *PISA 2022 Results (Volume I): The State of Learning and Equity in Education*. OECD. https://doi.org/10.1787/53f23881-en

Osborne, J., & Allchin, D. (2024). Science literacy in the twenty-first century: Informed trust and the competent outsider. *International Journal of Science Education*, 1–22.

Raymo, C. (1998). Scientific literacy or scientific awareness? In *American Journal of Physics*

(Vol. 66, Issue 9, pp. 752–752). American Association of Physics Teachers.

Riskawati, R., Yuliati, L., & Latifah, E. (2020). Penguasaan Konsep Suhu dan Kalor dengan Experiential Learning melalui Pembelajaran Destilasi Air Laut. *Jurnal Riset Pendidikan Fisika*, *5*(1), 59–64.

Roberts, J. (2018). From the editor: The possibilities and limitations of experiential learning research in higher education. In *Journal of Experiential Education* (Vol. 41, Issue 1, pp. 3–7). SAGE Publications Sage CA: Los Angeles, CA.

Santhalia, P. W., & Yuliati, L. (2021). An Exploration of Scientific Literacy on Physics Subjects within Phenomenon-based Experiential Learning. *Jurnal Penelitian Fisika Dan Aplikasinya (JPFA)*, *11*(1), 72–82.

Santhalia, P. W., Yuliati, L., & Wisodo, H. (2020). Building students' problem-solving skill in the concept of temperature and expansion through phenomenon-based experiential learning. *Journal of Physics: Conference Series*, *1422*(1), 012021.

Sjöström, J., Frerichs, N., Zuin, V. G., & Eilks, I. (2017). Use of the concept of *Bildung* in the international science education literature, its potential, and implications for teaching and learning. *Studies in Science Education*, *53*(2), 165–192. https://doi.org/10.1080/03057267.2017.1384649

Skare, M., & Soriano, D. R. (2021). How globalization is changing digital technology adoption: An international perspective. *Journal of Innovation & Knowledge*, *6*(4), 222–233.

Soh, T. M. T., Arsad, N. M., & Osman, K. (2010). The relationship of 21st century skills on students' attitude and perception towards physics. *Procedia-Social and Behavioral Sciences*, *7*, 546–554.

Symeonidis, V., & Schwarz, J. F. (2016). Phenomenon-based teaching and learning through the pedagogical lenses of phenomenology: The recent curriculum reform in Finland. *Forum Oświatowe*, *28*(2 (56)), 31-47-31–47.

Treacy, D. J., & Kosinski-Collins, M. S. (2011). Using the writing and revising of journal articles to increase science literacy and understanding in a large introductory biology laboratory course. *Atlas Journal of Science Education*, *1*(2), 29–37.

Vrana, R. (2019). Scientific Literacy Education Outside the Classroom: A Study in Acquisition of Knowledge and Skills About Science in Public Libraries in Croatia. In S. Kurbanoğlu, S. Špiranec, Y. Ünal, J. Boustany, M. L. Huotari, E. Grassian, D. Mizrachi, & L. Roy (Eds.), *Information Literacy in Everyday Life* (Vol. 989, pp. 522–531). Springer International Publishing. https://doi.org/10.1007/978-3-030-13472-3_49

Yuenyong, C. (2013). Enhancing scientific literacy in Thailand. *Global Studies of Childhood*, *3*(1), 86–98.

Yuliati, L., & Mufti, N. (2020). Acquisition of projectile motion concepts on phenomenon based physics' experiential learning. *Journal of Physics: Conference Series*, *1422*(1), 012007.