Volume 13 (4) 2025, 187-194
Jurnal Pelita Pendidikan
Journal of Biology Education
https://jurnal.unimed.ac.id/2012/index.php/pelita/index
eISSN: 2502-3217 pISSN: 2338-3003

E-WORKSHEET ORIENTED PROBLEM BASED LEARNING TO FOSTER SCIENTIFIC LITERACY: AN ANALYSIS OF PRESERVICE BIOLOGY TEACHERS' COMPETENCE IN DEVELOPING LEARNING TOOLS

Raja Novi Ariska[1*], Sailana Mira Rangkuty[2]
[1] *Biology Education Study Program, Faculty of Teacher Training and Education, Universitas Samudra, Aceh*
[2] *Biology Education Study Program, Faculty of Mathematic and Natural Science, Universitas Negeri Medan*

[*]Corresponding Author: rajanovia@unsam.ac.id

ARTICLE INFO:

Article History:

Received: August, 4th 2025
Revised : November, 3rd 2025
Accepted: Desember, 30th 2025

Keywords:

scientific literacy, problem-based learning, e-worksheet, preservice teachers, learning tools

ABSTRACT

This study investigates the competencies of preservice biology teachers in developing e-worksheets based on Problem-Based Learning (PBL) to enhance students' scientific literacy. Indonesian students' consistently low performance in international assessments such as PISA highlights the need for innovative learning tools to improve instructional quality. PBL has been recognized as an effective approach to promoting scientific literacy, and preservice teachers must be equipped to design high quality materials for 21st century classrooms. A qualitative descriptive method was applied with 10 seventh-semester biology education students enrolled in a TPACK course at Samudra University. Participants were tasked with designing e-worksheets integrated with PBL principles. Data were collected through rubric-based document analysis, evaluating pedagogical competence in PBL integration, scientific literacy alignment, technological content knowledge (TCK), and overall product quality. Findings show that most participants effectively integrated PBL components (79.5%), aligned designs with scientific literacy goals (82.5%) and overall quality of e-worksheet (82%), though challenges remain in contextualizing problems and optimizing technological content knowledge (70%). Strengthening preservice teachers' pedagogical and technological competencies is essential for preparing high-quality future educators.

How to Cite:
Ariska, R.N & Rangkuty, S.M. (2025). E-Worksheet Oriented Problem Based Learning To Foster Scientific Literacy: An Analysis Of Preservice Biology Teachers' Competence In Developing Learning Tools, 13(4): 187-194.

INTRODUCTION

Education serves as a cornerstone of national development, with the quality of a nation's education system closely linked to its overall progress (Hamidah & Ratnasari, 2020; Selmin et al., 2022). In the 21st century, educational demands have shifted toward fostering higher-order thinking, digital literacy, and scientific reasoning. Among the essential skills required is scientific literacy, which plays a vital role in enabling individuals to make informed decisions, participate meaningfully in a science-driven society (OECD, 2019).

Despite its importance, Indonesia continues to perform poorly in international science assessments such as PISA and TIMSS (El Islami et al., 2019; Tawil et al., 2025). This indicates a pressing need for innovative learning strategies and resources that effectively promote students' scientific understanding. One promising approach to address this problem is Problem-Based Learning (PBL), which emphasizes active learning through real-world problems that stimulate student inquiry and critical thinking (Arthamena et al., 2025).

Problem-Based Learning (PBL) is an instructional model that challenges students to work collaboratively to solve real-world problems. PBL involves interaction between stimuli and responses, where students engage in a two-way learning process with their environment. The environment provides input in the form of assistance and problems, while the brain interprets these inputs, allowing students to investigate, evaluate, analyze, and solve the problems effectively (Wati, 2020).

To facilitate learning through PBL, instructional tools are needed to guide the learning process in accordance with the syntax and objectives of PBL. Therefore, educators must possess the ability to develop e-learning based instructional materials that can be used to support and direct the learning process.

Electronic student worksheets are instructional materials that guide students through systematic learning steps, easily accessible via laptops, smartphones, or tablets (Zahara et al., 2021). E-worksheets are designed to support teachers in creating more engaging, interactive, and adaptive learning experiences tailored to students' needs. Simultaneously, digital tools like e-worksheets offer an opportunity to innovate learning experiences in a format suited to today's technological demands (Mufidah & Dwiningsih, 2024).

E-worksheets offer several advantages, such as saving time and space, making teaching and learning activities more practical and efficient (Suryaningsih & Nurlita, 2021). They can also include images, videos, and animations, which help present material more clearly and concretely (Amalia et al., 2022). Faradiba and Rachmadiarti (2020) state that including clear visuals can enhance students' learning interest and comprehension.

Preservice biology teachers play a crucial role in shaping future science learning. Their ability to design e-worksheets grounded in PBL principles directly impacts students' opportunities to develop scientific literacy. Despite its promise, research suggests that many preservice teachers struggle with the pedagogical and technological aspects required to implement inquiry-based or problem-based digital learning resources effectively (Khoerunnisa et al., 2025).

Therefore, this study investigates the competence of preservice biology teachers in developing PBL-integrated e-worksheets aimed at improving scientific literacy. Prior research has demonstrated that the use of PBL in combination with e-worksheet significantly improves students' critical thinking, problem-solving skills, and motivation which promote scientific literacy (Sirajudin et al., 2024; Azizah & Atun, 2025).

RESEARCH METHODOLOGY

This study employed a qualitative descriptive approach aimed at describing the competence of preservice biology teachers in developing Problem Based Learning (PBL) based e-worksheets to support scientific literacy.

Research Subjects

The subjects of this study were 10 seventh-semester Biology Education students at Samudra University who were enrolled in the TPACK (Technological Pedagogical Content Knowledge) course. These students were selected purposively based on the criteria that they had received instruction on the development of technology based instructional materials and had developed e-worksheets as part of their final course project.

Data Collection Technique

Data were collected through document analysis, focusing on the e-worksheet products developed by the students. Each product was assessed using a validated product assessment rubric consisting of four main aspects: Pedagogical competence in integrating Problem-Based Learning (PBL); Scientific Literacy Integration; Technology Content Knowledge (TCK), and e-Worksheet Quality.

Research Instrument

The primary instrument in this study was the product assessment rubric, which was developed based on the Problem-Based Learning syntax (Ibrahim & Nur, 2000), scientific literacy indicators (OECD, 2019), the TCK framework (Mishra & Koehler, 2006), and criteria for quality instructional materials. Each aspect consisted of 5 indicators, evaluated on a 1–4 scale, ranging from "not appropriate" to "very good."

Data Analysis Technique

Data were analyzed using qualitative descriptive analysis through the following steps: (1) Data Reduction: Identifying parts of the e-worksheet products relevant to the four assessment aspects. This method emphasizes rich, in-depth, and complete narrative descriptions to accurately represent real conditions and support effective data presentation (Farida, 2014).

Table 1. Presentation Category

Category	Average Value	Percentage
High	3,00- 4,00	> 79%
Medium	2,00-2,99	60% -79%
Low	1,00- 1,99	<60%

(2) Data Presentation: Organizing the assessment results in graph, tables and narrative descriptions. (3) Conclusion Drawing: Interpreting the data to obtain a general overview of the preservice biology teachers' competencies in integrating PBL and scientific literacy through the development of e-worksheets.

RESULT AND DICSUSSION

Preservice Biology Teachers' Competence in e-worksheet Development

The data in this study is collected from document analysis of e-worksheet developed by preservice biology teachers. Based on the research findings, the competence of preservice biology teachers in developing e-worksheets generally falls within the high category. The competence in integrating Problem Based Learning (PBL) reached 79.5%, which is classified as high. This indicates that preservice teachers are capable of effectively incorporating the PBL approach into e-worksheet development, thereby encouraging students to think critically and solve problems independently (Arthamena et al., 2025).

The scientific literacy integrations are also notably strong, with a score of 82.5%, placing them in the high category. This reflects a solid understanding of scientific concepts and the ability to relate them to real-life contexts, an

essential aspect in designing science-based learning materials (Sirajudin et al., 2024).

However, the Technological Content Knowledge (TCK) competence stands at 70%, which falls into the medium category. This suggests that there is still room for improvement in terms of integrating technology effectively with biology subject content (Khoerunnisa et al., 2025).

The overall quality of the e-worksheets developed by the preservice teachers was assessed at 82%, which is also considered high. This demonstrates that the e-worksheets produced meet quality standards in terms of content, design, and the integration of both technology and instructional approaches.

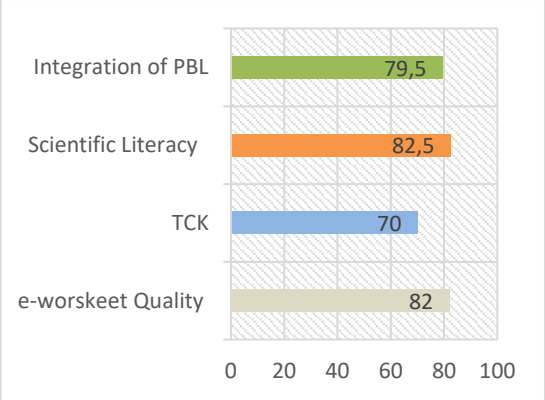

Figure 1. Competence in e-worksheet development based on PBL which promote scientific literacy

1. **Pedagogical Competence in integrating Problem-Based Learning (PBL) into e-worksheet**

Competence in integrating PBL into the development of e-worksheets is part of the pedagogical competence of preservice teachers . In this study, the assessment rubric includes five indicators based on the PBL syntax according to Ibrahim and Nur (2000). The following is an overview of the competence of biology education students as prospective teachers in integrating PBL into worksheets through instruction within an e-worksheet (Table 2).

Table 2. Competence in Integrating PBL

Integration of PBL	Mean	%	Category
Oriented students into contextual and complex problems	3,5	87,5	High
Organize students to discuss and work collaboratively	3,1	77,5	Medium
Guide students to think critically and conduct an investigation	3,2	80	High
Encourage students to create solutions and Presentations	3	75	Medium
Evaluation and Reflection	3,1	77,5	Medium

The analysis of preservice biology teachers' competence in implementing key aspects of student-centred learning through e-worksheet development shows varied yet generally positive results.

Preservice teachers demonstrated a strong ability to orient students toward contextual and complex problems, achieving a score of 87.5%, categorized as high. This reflects their capability to engage students in real-life, meaningful issues that stimulate inquiry and deeper understanding, an essential foundation of problem-based learning through instruction within the e-worksheet (Sirajudin et al., 2024).

In addition, they showed high competence in guiding students to think critically and conduct investigations, with a score of 80%. This suggests they are effectively designing learning tasks that prompt students to ask questions, analyse information, and carry out scientific investigations, which supports the development of inquiry skills and scientific reasoning (Arthamena et al., 2025).

However, several areas fall within the medium category, indicating the need for further development. First, the ability to organize students to discuss and work collaboratively scored 77.5%. This suggests that while collaboration is encouraged, preservice teachers may still need support in facilitating effective group dynamics and interactive dialogue the

competence to encourage students to create solutions and deliver presentations was assessed at 75%, pointing to moderate ability in promoting creativity and communication skills key elements in student centered and performance-based learning through the e-worksheet.

Lastly, their ability to implement evaluation and reflection activities within e-worksheet scored 77.5%, also in the medium category. This indicates a need to strengthen strategies that help students assess their learning processes and outcomes critically.

In summary, while preservice biology teachers show strong capabilities in fostering problem orientation and investigative thinking, there is still room to improve in supporting collaboration, encouraging student-generated solutions, presentation skills, and fostering reflective practices. Addressing these aspects through targeted training could further enhance the quality and impact of the e-worksheets they develop.

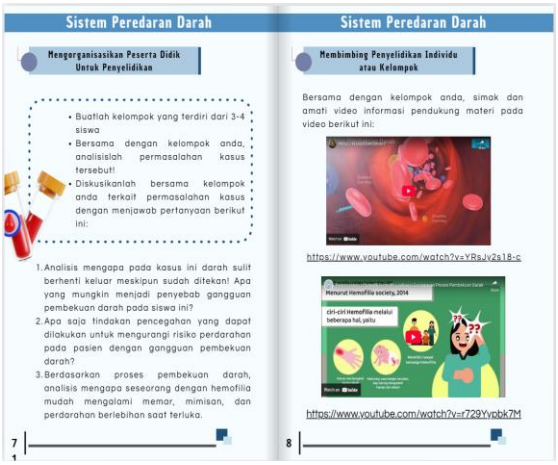

Figure 2. Example of Integrated PBL syntax within e-worksheet

2. Scientific Literacy Integration

In terms of scientific literacy integration, the findings reveal the extent to which preservice biology teachers were able to incorporate scientific literacy indicators into their e-worksheet designs, reflecting both their pedagogical understanding and their ability to translate these competencies into practical learning activities. The data of preservice biology teachers' competence is presented in table 3.

Table 3. Competence in Integrating Scientific Literacy

Scientific Literacy	Mean	%	Category
Includes questions or activities that require understanding of scientific concepts (content).	3,5	87,5	High
Provides data/facts for students to analyze (scientific process).	3,4	85	High
Designs tasks involving real-world contexts or social issues (context).	3,3	82,5	High
Develops questions based on scientific argumentation (evidence-based reasoning).	3,1	77,5	Medium
Provides space for reflection/conclusion to encourage scientific thinking.	3,2	80	High

Preservice teachers demonstrated a high level of competence in integrating components of scientific literacy into their e-worksheets. Most designs effectively included questions or activities that required an understanding of scientific concepts (87.5%), provided data or factual information for students to analyze scientific processes (85%), and incorporated tasks reflecting real-world contexts or social issues (82.5%).

These results indicate a strong capacity to engage students with relevant content and promote problem-based learning. In addition, many e-worksheets provided opportunities for students to reflect and draw conclusions (80%), which also falls within the high category. However, the development of questions grounded in scientific argumentation or evidence-based reasoning scored slightly lower (77.5%, medium category), suggesting the need

to further strengthen preservice teachers' ability to cultivate deeper reasoning and evidence-based discussion among students.

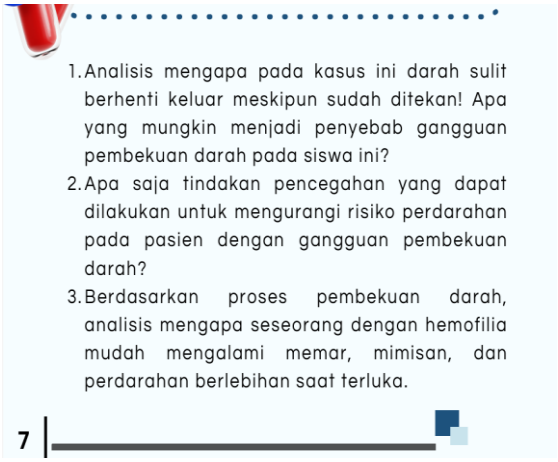

Figure 3. Example of instructional question- promotes scientific understanding within e-worksheet

This finding aligns with previous research indicating that while preservice teachers are generally confident in embedding conceptual and contextual aspects of scientific literacy, they often face challenges in guiding students to construct arguments supported by empirical evidence. Addressing this gap through targeted training and scaffolded practice could enhance the depth and quality of students' scientific reasoning in future classroom applications (Azizah & Atun, 2025).

3. Technological Content Knowledge (TCK)

In terms of Technological Content Knowledge (TCK), the analysis focuses on how preservice biology teachers selected and integrated digital tools to support the development of e-worksheets.

Table 4. TCK competence

TCK	Mean	%	Category
Selects appropriate digital media to create e-worksheet	3,5	87,5	High
Uses simulations or interactive videos to demonstrate phenomena.	3	75	Medium
Embeds hyperlinks, videos, or diagrams into the e-worksheet.	3,1	77,5	Medium
Adapts technological features to the characteristics of the content.	2,7	67,5	Medium
Design technology based assessment align with the content	2,5	62,5	Medium

The preservice teachers demonstrated high competence in selecting appropriate digital media to create e-worksheets (87.5%), indicating confidence in choosing tools that match their instructional goals. In this task, they use varies platform to create e-worksheet like liveworksheets, Heyzine Flipbook, and Flipbook PDF. However, their ability to use and integrate more complex or dynamic technological features remained in the medium category, including the use of simulations or interactive videos (75%), embedding hyperlinks and multimedia content (77.5%), and adapting technological features to suit the characteristics of the content (67.5%). These findings suggest that while preservice teachers are adept at utilizing basic digital media, they may require additional training to explore and implement advanced features that could enhance interactivity, engagement, and content delivery (Faradiba & Rachmadiarti, 2020; Zahara et al., 2021; Mufidah & Dwiningsih, 2024).

Figure 4. Platform used in developing e-worksheet (Heyzine Flipbooks, Flipbook PDF, and Liveworksheets**)**

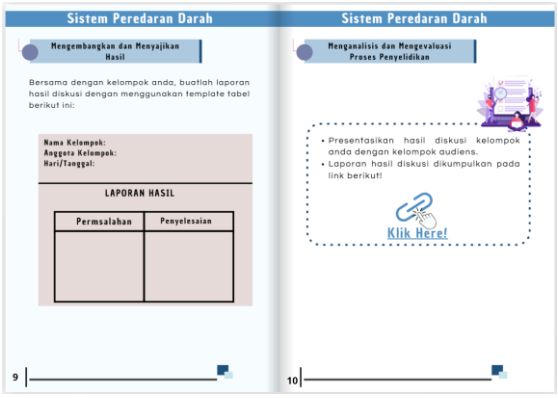

Figure 5. Embedding hyperlink within the e-worksheet

4. e-worksheet Quality

In terms of overall quality, the evaluation focused on key aspects that determine the effectiveness and usability of the e-worksheets developed by preservice biology teachers. The data of e-worksheet quality is presented in Table 5.

Table 5. Preservice teachers' competence in e-worksheet development based on e-worksheet quality

e-worskeet Quality	Mean	%	Category
Clarity of Instructions	3,6	90	High
Logical Structure and Organization	3,5	87,5	High
Visual Design	3,3	82,5	High
Interactive Elements	2,7	67,5	Medium
Langauge and Readibility	3,3	82,5	High

The overall quality of the e-worksheets developed by preservice teachers was rated as high in several critical areas: clarity of instructions (90%), logical structure and organization (87.5%), visual design (82.5%), and language/readability (82.5%). These results reflect their ability to design clear, structured, and accessible learning materials. However, the integration of interactive elements within the e-worksheets was rated 67.5% (medium), indicating that while the worksheets are well crafted, they could benefit from more engaging and interactive features to enhance student participation and digital learning experiences.

CONCLUSION

In summary, preservice biology teachers demonstrate strong competence in designing e-worksheets that promote scientific literacy and exhibit high instructional quality. However, further training is recommended to improve their ability to incorporate advanced technological features, develop technology-aligned assessments, and enhance interactive elements. Strengthening these areas will contribute to more dynamic, engaging, pedagogically effective e-learning materials and improve the quality of preservice teachers as future educators.

REFERENCES

Amalia, D., Nugraheni, R., & Pratiwi, N. D. (2022). The development of interactive e-worksheets to support science learning. *Jurnal Inovasi Pendidikan IPA, 8*(1), 45–53.

Arthamena, A. F., Sutopo, S., & Nurhadi, D. (2025). Enhancing students' critical thinking through problem-based learning: A quasi-experimental study. *Journal of Science Education Research, 11*(2), 78–89.

Azizah, N., & Atun, S. (2025). Development of PBL-based worksheets to improve students' scientific literacy and motivation. *Jurnal Pendidikan Sains, 13*(1), 22–33.

El Islami, R. A. Z., Surya, E., & Hasratuddin. (2019). Analysis of Indonesian students' scientific literacy in PISA and efforts to improve it through contextual learning. *Journal of Education and Practice, 10*(12), 95–102.

Faradiba, R., & Rachmadiarti, F. (2020). The effect of visual-based e-worksheets on students' interest and understanding in biology learning. *BioEdu, 9*(3), 567–574.

Farida, I. (2014). Teknik analisis data secara kualitatif dalam penelitian pendidikan. *Jurnal Penelitian Pendidikan, 15*(1), 34–44.

Hamidah, A., & Ratnasari, L. (2020). Education quality as the foundation of national development: A case study of Indonesia. *Indonesian Journal of Educational Review, 7*(1), 14–24.

Ibrahim, M., & Nur, M. (2000). *Pengajaran berbasis masalah*. Surabaya: University Press.

Khoerunnisa, R., Latifah, S., & Anggraini, T. (2025). Challenges in developing digital teaching materials among preservice teachers. *Jurnal Teknologi Pendidikan, 27*(2), 155–165.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054.

Mufidah, N., & Dwiningsih, K. (2024). Designing digital worksheets to support inquiry-based science learning. *Jurnal Pendidikan IPA Indonesia, 13*(1), 112–122.

OECD. (2019). *PISA 2018 results (Volume I): What students know and can do*. Paris: OECD Publishing. doi:10.1787/5f07c754-en

Selmin, R., Yuliana, L., & Prasetya, A. (2022). The relationship between education and national development: An Indonesian context. *Jurnal Sosial Humaniora, 10*(3), 78–87.

Sirajudin, S., Rahmah, N., & Arifin, M. (2024). The effectiveness of problem-based learning integrated with digital worksheets on scientific literacy. *International Journal of Science Education, 16*(2), 65–74.

Suryaningsih, R., & Nurlita, T. (2021). Kepraktisan penggunaan e-worksheet dalam pembelajaran daring. *Jurnal Teknologi Pendidikan, 23*(1), 88–96.

Tawil, M., Hasanah, N., & Yusuf, M. (2025). Indonesian students' performance in TIMSS and strategies for improvement. *Journal of Educational Reform, 9*(1), 33–42.

Wati, R. (2020). Pembelajaran berbasis masalah dalam meningkatkan keterampilan berpikir kritis siswa. *Jurnal Inovasi Pendidikan Sains, 4*(2), 123–131.

Zahara, A., Nugroho, M., & Prameswari, N. (2021). E-worksheets as digital teaching materials: Benefits and implementation. *Jurnal Pendidikan Biologi, 10*(1), 19–27.