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The Effects of Project-Based Learning Using AI-Assisted Tools on Biology Pre-service Teachers' Ability to Develop E-Worksheets: A Rigorous Analysis

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ABSTRACT

Introduction. The integration of AI in education has gained significant attention, and its potential to enhance teaching and learning outcomes is increasingly recognized. *This study aimed* to investigate whether the combination of Project-Based Learning (PBL) and artificial intelligence (AI) could improve pre-service teachers' pedagogical skills and the quality of their instructional materials.

Methods. A quantitative, pre-experimental design with a one-group pretest-posttest format was employed. Thirty pre-service biology teachers participated in the study. Data were collected using a product assessment rubric to evaluate the quality of the e-worksheets created before and after the intervention. Additionally, a post-intervention questionnaire was administered to gather participants' perceptions and experiences. Paired samples t-tests were conducted to analyze the significance of the changes in e-worksheet quality.

Results. The findings revealed a significant improvement in the quality of e-worksheets developed by the pre-service teachers after participating in the AI-integrated PBL ($M = 36.83$, $t = 26.33$, $p = .000$). All aspects of the assessment covering content, design, functionality, accessibility, and technicality increased significantly ($p = .000$). This implied that the implementation of AI-assisted PBL enhanced pre-service teachers' ability in developing biology e-worksheets. At the end of the class session, they also showed a very positive response ($N = 30$, $Q = Q4$) towards the experience of learning how to develop biology e-worksheets using AI. They agreed that AI-assisted PBL could enhance their creativity, problem-solving skills, and technology integration abilities.

Conclusion. This study highlights the potential of AI-assisted PBL as a valuable approach for enhancing pre-service biology teachers' ability to develop e-worksheets, especially in the aspects of content, design, functionality, accessibility, and technicality. This study also gives a worthy learning experience in the age of AI by conducting an AI-powered learning mode. Thus, the findings of this study imply that teacher education programs should consider the integration of AI to help biology preservice teachers master AI-enhanced pedagogy and prepare them to be technologically literate teachers in the future.

KEYWORDS

Project-based learning, AI-assisted tools, e-worksheet, biology preservice teachers

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INTRODUCTION

Currently, the critical awareness of quality education should be considered by many education stakeholders because UN international initiatives in education have prioritized it as one of the sustainable development goals (SDGs). This influences UNESCO to initiate its Futures of Education Initiative and Global Education Coalition that focus on developing technology-enhanced learning modes as efforts to cope with the advancement of technology and information. One of which is to make use of artificial intelligence in learning scenarios. Artificial intelligence can be a vital tool that needs serious thought since its worst-use management might hamper the success of the learning process. Thus, quality education should not only reflect its mindfulness but also meaningfulness for the lives amidst the era of artificial intelligence.

Artificial intelligence tools, familiarly known as AI-assisted tools, have rapidly evolved and emerged in biology education over the last decades. Many studies have profoundly looked at the diverse research focuses regarding AI-assisted tools. Several studies have explored the AI-assisted tools biology preservice teachers use to accomplish task assignments [1]. Most of the results showcase that ChatGPT has become the most familiar AI-assisted tool in assisting the conduct of the biology teaching and learning process [2]. Several AI-assisted tools are also used to support the learning process, such as Canva, Gemini, Copilot, Gamma, Intelligent Tutoring System (ITS), and Summarization Integrated Development Environment (SIDE) [3; 4]. In addition, some studies convey that students portray positive attitudes toward AI-integrated biology learning because the tools help them accentuate their learning performance [5]. Other studies have examined how AI-assisted tools augment biology subject mastery by promoting autonomous learning [3]. These phenomena show that AI-assisted tools have been used in biology teaching and learning.

Among the above diverse scopes, limited studies have investigated the effectiveness of AI-assisted tools in improving biology preservice teachers' ability to develop e-worksheets. Many of them only worked under systematic literature review design and case studies [6], and, to the best of the researcher's knowledge, no experimental study was undertaken to examine the influence of AI-assisted tools in enhancing biology preservice teachers' ability to develop student worksheets. Indeed, some studies might have worked in developing both worksheets or e-worksheets for biology students [7], but none of them integrated AI-assisted tools. In addition, there is an absenteeism of information regarding how biology preservice teachers worked collaboratively with AI-assisted tools in a project-based learning scenario. This gap must be immediately addressed since the teaching and learning mode integrating human-AI collaboration has been the current issue in many research fields regarding AI-integrated instructions [8]. The information is important as a reference for biology teachers and preservice teachers to advance their teaching best practices.

In addition, biology preservice teachers are also less exposed to AI program introduction. This is mainly forgotten by teacher education institutions that focus on the mastery of specified knowledge and competence in Biology. In other words, many teacher education programs only develop preservice teachers' teaching skills and specific ecological knowledge without providing technology-enhanced training segments [9]. Currently, the integration of AI in a learning process presumes that Biology preservice teachers are familiar with the use of AI programs, know the characteristics, and understand the troubleshooting of any technical difficulties. This stereotype justifies the lack of preservice teachers' competence in mastering AI programs and using them to support their learning process, such as devising e-worksheets.

To address the above gaps, the present study intends to investigate the effects of a project-based learning model using AI-assisted tools on biology preservice teachers' ability to develop e-student worksheets and describe their responses and e-worksheet products. This study shows how project-based learning using AI-assisted tools is designed and used to enhance biology preservice teachers' ability to develop e-worksheets. This learning scenario was used as a treatment in a pretest-posttest one-group design. Thus, the effectiveness of the treatment could be undertaken. There are three research questions postulated in the study:

Research question 1: What is the biology preservice teachers' ability to develop e-worksheets?

Research question 2: Does project-based learning use of AI-assisted tools affect biology preservice teachers' ability to develop e-worksheets?

Research question 3: What are the biology preservice teachers' responses on the undertaken AI-integrated teaching?

The present study also encloses the short-term training process of introducing and using several AI-assisted tools. The AI-assisted tools involved in the present study have been recommended by several prior research in devising learning or teaching tools [10]. This study is limited in the scope of biology preservice teachers who have accomplished microteaching, instructional design, and introductory Biology education courses in Indonesia. Therefore, generalizing the present study's findings is extraneous to another research setting.

THEORETICAL FRAMEWORKS

Artificial intelligence (AI) has demonstrated significant advancements across various sectors, including education, with notable implications for biology education [1]. Most of the results showcase that ChatGPT has become the most familiar AI-assisted tool in assisting the conduct of the biology teaching and learning process [2]. Several AI-assisted tools are also used to support the learning process [3; 4]. In addition, some studies convey that students portray positive attitudes toward AI-integrated biology learning because the tools help them accentuate their learning performance [5]. Many of them only worked under systematic literature review design and case studies [6]. Indeed, some studies might have worked in developing both worksheets or e-worksheets for biology students [7], but none of them integrated AI-assisted tools. This gap must be immediately addressed since the teaching and learning mode integrating human-AI collaboration has been the current issue in many research fields regarding AI-integrated instructions [8; 9].

As a transformative learning tool, AI leverages its capacity to analyze data, deliver real-time feedback, and adapt instructional materials to meet diverse learning needs [11]. A key advantage of AI in biology education lies in its ability to personalize the learning experience, catering to individual learning styles and varying rates of comprehension [12]. For instance, students struggling with complex concepts such as photosynthesis can receive tailored explanations and targeted exercises to reinforce their understanding. Additionally, AI enhances access to a wide array of educational resources [13]. Through AI-driven platforms, students can explore extensive digital libraries containing scientific publications, instructional videos, and the latest research articles in biology. This facilitates engagement with cutting-edge developments in the field, fostering a deeper and more current understanding of biological concepts. AI also supports immediate clarification of student inquiries through interactive tools such as AI-powered chatbots [12]. These chatbots can elucidate intricate topics, address subject-specific questions, and recommend supplementary resources, thereby benefiting students who may hesitate to ask questions in traditional classroom settings or those studying independently. Furthermore, AI enables the simulation of biological experiments that are either impractical or hazardous to conduct in school laboratories [14]. These virtual simulations provide a safe and interactive environment for students to explore biological processes, enhancing their comprehension without the risks associated with physical experimentation. Collectively, these applications underscore the potential of AI to revolutionize biology education by making it more personalized, accessible, and engaging.

Despite its transformative potential, the integration of artificial intelligence (AI) into biology education is not without challenges. A critical consideration is ensuring that AI complements, rather than replaces, the essential role of human interaction in the learning process [11; 15]. Educators remain indispensable in fostering meaningful discussions, motivating students, and elucidating complex concepts in an accessible manner [16]. While AI serves as a powerful tool to enhance student understanding, broaden access to information, and create more engaging learning experiences [14], its optimal application requires a balanced approach that leverages its strengths without undermining the human elements of teaching. When implemented effectively, AI can act as a valuable partner in biology education, equipping the next generation of scientists with the knowledge and innovation skills necessary to address future challenges.

The incorporation of AI into project-based learning (PBL) has introduced new opportunities to enhance the efficacy and quality of students' educational experiences [17]. PBL, an instructional approach that emphasizes active student engagement in real-world projects, fosters critical thinking and creativity [18]. By integrating AI into PBL, educators can further enrich the learning process

through personalized learning pathways. AI's data analysis capabilities enable the identification of individual students' interests, strengths, and areas for improvement. For instance, in an environmental research project, AI can assist students in selecting topics aligned with their interests while providing curated resources to support their exploration. This tailored approach not only enhances relevance but also deepens the meaningfulness of the learning experience, ensuring that students remain engaged and motivated throughout their educational journey.

Artificial intelligence (AI) also plays a pivotal role in fostering collaboration among student teams as one of the prerequisites in a collaborative learning project. By leveraging AI-powered platforms, students can communicate and collaborate more efficiently, streamlining group dynamics and enhancing productivity [19]. AI-driven project management systems can automate task organization, send reminders for deadlines, and offer feedback on project progress, enabling students to concentrate on the substantive aspects of their work rather than logistical challenges. This optimization of workflow ensures that teams can focus on achieving high-quality outcomes. In an educational context, AI further enhances the learning process by providing real-time feedback during project development. For instance, when students draft presentations or reports, AI tools can analyze the content and offer constructive suggestions for improving both structural coherence and substantive depth [12]. This immediate feedback not only elevates the quality of the final deliverables but also facilitates experiential learning, allowing students to identify and rectify errors in real time. Such iterative refinement fosters a deeper understanding of the subject matter and cultivates critical thinking and problem-solving skills, which are essential for success in biology education and beyond.

Based on the above reviews on the topics of AI tools used as a learning media in project-based learning (PBL), there are some significant transformation underpinnings that most biology teachers and educators need to be aware of. First, AI enables the personalization of learning experiences by analyzing individual needs, such as students' learning styles, learning speed, and interests, thus ensuring deeper engagement in real-world projects. This would accommodate the personalized learning progress when facing individual project work. Second, AI supports team collaboration through platforms that optimize project management, such as task organization, deadline reminders, and automated feedback, allowing students to focus on the content and outcomes of the project. However, to the best of the researchers' knowledge and the reviewed studies, there have been no studies specifically investigating the effects of AI-powered PBL on biology preservice teachers' ability to develop e-worksheets, thus, the present study aims to respond to such research void.

METHODS

This study used a pre-experimental one-group pretest-posttest design with a quantitative research approach [20]. Thirty biology preservice teachers were involved in the study using several inclusion criteria, such as being enrolled in the teacher education program at one of the state universities in Indonesia and having accomplished microteaching, instructional design, and introductory Biology education courses. Table 1 shows the participants' demographic data.

Table 1

Participants' Demographic Data

Aspect	N	Percentages (%)
Gender		
Male	12	40%
Female	18	60%
Enrolled in the Biology Teacher Education Program	30	100%
Having accomplished the microteaching course	30	100%
Having accomplished instructional design	30	100%
Having accomplished an introductory Biology education course	30	100%

Data were collected using a product assessment sheet and questionnaire. First, the product assessment sheet was developed to assess biology preservice teachers' ability to develop e-worksheets before and after the treatment. Before the treatment, the biology preservice teachers had participated in a conventional meeting developing e-worksheets. They were asked to make the e-worksheets at the end of the meeting. After the treatment, they were asked to make new e-worksheets on the same topics to portray differences in produced products. Table 2 shows the assessment indicators for assessing the e-worksheets used before and after the treatment using project-based learning with AI-assisted tools. Appendix 1 encloses the scoring rubric for each aspect.

Table 2

A Blueprint of Assessment Indicators

Aspect	Indicators	Number of Items	References
Content	Material completeness Material clarity Material relevance Easy-to-follow instructions Providing student's reflective thinking	1 2 3 4 5	[21; 22]
Design	Interesting e-worksheet cover An exemplary sequence of worksheets Attractive designs for the contents No disturbing visualizations (e.g., pictures and use of colors)	6 7 8 9	
Functionality	Promoting autonomous learning Exposing students to review materials that had been learned Promoting reflective thinking Measuring students' material comprehension	10 11 12 13	
Accessibility	Ease to access	14	
Technicality	Easy to use (using affordable technology, e.g., hardware and software)	15	

Second, the response questionnaire was used to determine the feedback from the biology preservice teachers regarding implementing project-based learning using AI-assisted tools. The questionnaire used a five-point Likert's scaling method from strongly disagree (1) to agree (5) strongly. Before it was used in this study, it was previously validated by five experts in Biology Education. It showed that the content validity ratio (CVR) was +1.00, and the content validity index (CVI) was 1.00. This meant that the experts agreed that the questionnaire could be used in this study. In addition, at the end of the questionnaire, an open question was enclosed to reveal the biology preservice teachers' feelings and challenges. The answers to this question were used to confirm the results of the response questionnaire. Table 3 shows the blueprint of the questionnaire along with the CVR and CVI results.

Table 3

A Blueprint of Response Questionnaire

Items	CVR	References
I understand how to make student e-worksheets easily.	+1.00	[23; 24]
I experience more autonomous learning when developing the e-worksheet.	+1.00	
I know several AI-assisted tools to support the making of e-worksheets.	+1.00	
Through the project-based learning model, I can apply several AI-assisted tools collaboratively to make good content e-worksheets.	+1.00	
I also can use several AI-assisted tools to create more interesting designs for the e-worksheet.	+1.00	

I agree that AI-assisted tools should be integrated into every biology learning process because they provide significant assistance.	+1.00	
Even the AI-assisted tools can provide any information, I am sure that humans are still required to plan the project.	+1.00	
I can improve my learning performance, especially in coping with developing biology e-worksheets.	+1.00	
I recommend using AI-assisted tools to help teachers or students accomplish their tasks.	+1.00	
On the other hand, there must be learning strategies using AI-assisted tools that must be learned.	+1.00	
CVI	1.00	

The quantitative data were inputted into IBM SPSS 25 and analyzed using descriptive statistics tests and paired sample t-tests. A descriptive statistics test was used to analyze the quantitative data obtained from the product assessment before and after the project-based learning undertaken using AI-assisted tools. The obtained M scores were transformed into M% and categorized using Swanson's categorization: M% < 25% (Q1= very low), 25% ≤ M% < 50% (Q2 = low), 50% ≤ M% ≤ 75% (Q3 = high), and M % > 75% (Q4 = very high), it was also used to analyze the data from the response questionnaire and obtain the M scores, which were further transformed into M% and categorized using Swanson's categorization: M% < 25% (Q1= very negative response), 25% ≤ M% < 50% (Q2 = negative response), 50% ≤ M% ≤ 75% (Q3 = positive response), and M % > 75% (Q4 = very positive response) [23; 25]. The paired sample t-test was employed to see whether the undertaken project-based learning using AI-assisted tools could enhance biology preservice teachers' ability to develop e-worksheets. In addition, the obtained qualitative data from the open question was used as data triangulation to confirm the quantitative data from the results of the response questionnaire.

Procedures for Conducting Project-Based Learning Using AI-Assisted Tools

The researchers, acting as the classroom lecturer, conducted the class in two meetings. The first meeting was used to carry out conventional learning in developing e-worksheets, and the second meeting was used to carry out project-based learning using AI-assisted tools in developing e-worksheets. In the conventional learning mode conducted in the first meeting, the researchers only have 100 minutes to conduct a class with a lecturing mode. In the pre-learning activities, they introduced some examples of biology e-worksheets obtained from various sources. They also discussed the appearance of the e-worksheets with the pre-service teachers. After having an interesting discussion about the examples, they gave a lecture on the functions of e-worksheet along with what aspects should be considered when developing it. In this while learning, the pre-service teachers only listened to the lecturers' explanations and the slides provided. Once or twice, the pre-service teachers asked questions to strengthen their comprehension. In the post-learning activities, the lecturers asked the pre-service teachers to develop e-worksheets. Each pre-service teacher got one biology topic as an e-worksheet theme. The lecturers used a lottery to conduct fairness. The topics included Plant Growth and Development, Biotechnology, Immune System, Nervous System Disorders, Human Respiratory System, Digestive System, Invertebrates, Excretory System, Bioentrepreneur, and Viruses. These topics were determined based on the biology topics learned by higher secondary school students in the third grade that were written in the Indonesian Merdeka Curriculum. After that, the lecturers asked the pre-service teachers to start working on the e-worksheet development and continue the process at home if it was unfinished. They also gave a deadline of three days to submit their work. After the submission time, they assessed the e-worksheets using the product assessment sheet and rubric (see Table 2 and Appendix 1).

In the second meeting (a week after the first meeting), the lecturers came to the class with the same objective, namely, developing e-worksheets on Biology topics. In the pre-learning activities, the lecturers showed a learning video that promoted artificial intelligence tools (a.k.a. AI-assisted tools) in creating a workbook. Then, the lecturers discussed a bit about AI-assisted tools with the pre-service teachers. They also made an interesting discussion about how AI-assisted tools could be used to support the pre-service teachers' learning and working processes. Coming to the main learning activities, the lecturers introduced some AI-assisted tools that could be used to develop e-worksheets, such as Canva, Google Translate, Perplexity, Deepseek, Gemini AI, QR Code Generator, Copilot AI, AI

Image Generator, Liveworksheets, Assemblr Studi, and ChatGPT. They also portrayed the functions of each introduced AI-assisted tool practically to give the pre-service teachers a vicarious experience. They also opened a question-answer session to ensure the preservice teachers comprehended the tools' functions and usage procedures. Then, the lecturers explained the steps of developing an e-worksheet and showed what AI-assisted tools could be used in each step. Table 4 shows the steps of developing an e-worksheet with the assistance of AI-assisted tools. After explaining the development steps, the lecturers asked the pre-service teachers to appropriate the steps to develop an e-worksheet with a similar biology topic they got in the first meeting. In the post-learning activities, the lecturers asked them to finish the e-worksheet and continued it at home to finish. The pre-service teachers were asked to submit the final e-worksheet three days after the class. At last, the lecturers assessed the e-worksheets using the product assessment sheet and rubric.

Table 4

Steps of Developing E-Worksheets Using the Assistance of Artificial Intelligence

Steps	Pre-service teachers' activities	Recommended AI-assisted tools
Brainstorming	Enriching knowledge of the biology topics, searching relevant examples of e-worksheet, and exploring the instructional objectives of the biology topics	Gemini AI, ChatGPT, Copilot AI, Perplexity, Deepseek, and Google Translate
Planning	Planning the contents of the e-worksheet, determining the design of the e-worksheet, and the references	Canva-mind mapping features, Canva worksheet, AI image generator
Developing	Developing the planning stage	• Developing contents: Gemini AI, ChatGPT, Copilot AI, Perplexity, and Deepseek. • Comprehending contents: Google Translate and Deepseek. • Developing design: AI Image generator, Canva, Liveworksheets, and Assemblr Studi.
Evaluating	Reviewing the contents and design of the e-worksheet and revising the unnecessary things	(manual evaluation)

Ethical Issues

This study tried to uphold the research ethic even though the institution had no ethical committee. The participants' detailed information was not disclosed per the researcher's commitment to confidentiality. The preservice teachers were given a consent form and agreed to participate in the study. This meant that this study did not physically and mentally force the participants to join the research. The data obtained were stored in Google Forms and Google Docs, which only the researcher could access.

RESULTS

Biology Preservice Teachers' Ability to Develop E-Worksheets Before and After the Treatment

First, this study portrayed the biology preservice teachers' ability to develop e-worksheets before the treatment or in the first meeting. Table 5 shows the preservice teachers' ability to develop e-worksheets in the conventional learning mode.

According to Table 5, the biology preservice teachers' ability to develop e-worksheets in Biology topics was categorized as low. The content aspects were very low and did not provide students with reflective thinking exposures. Moreover, the materials were less complete, clear, and relevant. This might be because the product development perceived less material brainstorming and resources. As the other four aspects also had low skills, the preservice teachers could not create interesting and attractive designs that could enhance functionality and accessibility. Moreover, the product was not easy to use since the provided e-worksheets were locked with some access permission and invalid

links. To compare this result, Table 6 shows the preservice teachers' ability to develop e-worksheets using AI-assisted tools in a project-based learning mode.

Table 5

Preservice Teachers' Ability to Develop E-Worksheets in the Conventional Learning Mode

Aspect	Indicators	SD	M	M%	Q Category
Content	Material completeness	.406	1.20	30%	Low
	Material clarity	.253	1.06	26.50%	Low
	Material relevance	.345	1.13	28.25%	Low
	Easy-to-follow instructions	.220	1.06	26.50%	Low
	Providing student's reflective thinking	.000	1.00	25%	Low
Design	Interesting e-worksheet cover	.456	1.13	28.25%	Low
	A good sequence of worksheets	.253	1.13	28.25%	Low
	Attractive designs for the contents	.253	1.13	28.25%	Low
	No disturbing visualizations (e.g., pictures and use of colors)	.208	1.03	25.75%	Low
Functionality	Promoting autonomous learning	.456	1.13	28.25%	Low
	Exposing students to review materials that had been learned	.253	1.06	28.25%	Low
	Promoting reflective thinkingMeasuring students' material comprehension	.253	1.06	28.25%	Low
		.208	1.13	25.75%	Low
Accessibility	Ease to access	.490	1.36	34%	Low
Technicality	Easy to use (using affordable technology, e.g., hardware and software)	.504	1.43	35.75%	Low

Table 6

Preservice Teachers' Ability to Develop E-Worksheets Using AI-Assisted Tools in Project-Based Learning Mode

Aspect	Indicators	SD	M	M%	Q Category
Content	Material completeness	.406	3.80	95%	Very high
	Material clarity	.253	3.86	96.50%	Very high
	Material relevance	.345	3.76	94%	Very high
	Easy-to-follow instructions	.220	3.83	95.75%	Very high
	Providing student's reflective thinking	.000	3.70	92.50%	Very high
Design	Interesting e-worksheet cover	.466	3.63	90.75%	Very high
	A good sequence of worksheets	.409	3.76	94%	Very high
	Attractive designs for the contents	..449	3.76	94%	Very high
	No disturbing visualizations (e.g., pictures and use of colors)	.430	3.73	93.25%	Very high
Functionality	Promoting autonomous learning	.449	3.87	96.75%	Very high
	Exposing students to review materials that had been learned	.430	3.90	97.50%	Very high
	Promoting reflective thinkingMeasuring students' material comprehension	.305	3.76	94%	Very high
		.430	3.73	93.25%	Very high
Accessibility	Ease to access	.406	3.80	95%	Very high
Technicality	Easy to use (using affordable technology, e.g., hardware and software)	.449	3.73	93.25%	Very high

According to Table 6, the Biology preservice teachers' ability to develop e-worksheets using AI-assisted tools in the undertaken project-based learning mode was in a very high category. This meant that AI-assisted tools helped them develop the content, accelerate the design, improve the

functionality, and promote easy access and technicality. The core function of the student worksheet was also accommodated by the model since the functionality of exposing students to review previous materials got the highest M% among other aspects. Therefore, Tables 4 and 5 concluded that Biology preservice teachers showed better skills in developing e-worksheets using AI-assisted tools conducted in a project-based learning mode. However, it was necessary to see the statistical analysis of how the effect of project-based learning using AI-assisted tools contributed to the advancing skills (see the following subsections).

Effects of Project-Based Learning Using AI-Assisted Tools on Biology Preservice Teachers' Ability to Develop E-Worksheets

This study conducted a paired sample t-test to examine the effect of the undertaken project-based learning model using AI-assisted tools to enhance biology preservice teachers' ability to develop e-worksheets. Table 7 shows the results of the paired sample t-test.

Table 7

Effect of Project-Based Learning Model Using AI-Assisted Tools on Ability to Develop E-Worksheets

Pairs	M	t	df	Sig (2-tailed)
Pair 1 (Aggregate)	36.83	26.33	29	.000*
Pair 2 (Content)	2.44	13.12	29	.000*
Pair 3 (Design)	2.41	8.97	29	.000*
Pair 4 (Functionality)	2.45	6.34	29	.000*
Pair 5 (Accessibility)	2.58	8.82	29	.000*
Pair 6 (Technicality)	2.58	7.83	29	.000*

Regarding Table 7, the undertaken project-based learning using AI-assisted tools significantly affected biology preservice teachers' ability to develop e-worksheets. The treatment was proven effective in enhancing every subskill of the preservice teachers' ability to develop e-worksheets, e.g., content, design, functionality, accessibility, and technical aspects. Table 6 also implied that project-based learning using AI-assisted tools improved preservice teachers' ability to develop e-worksheets compared to the conventional method, which only emphasized material comprehension and had less opportunity for appropriate technologies.

Biology Preservice Teachers' Responses on AI-Integrated Project-Based Learning Model

This study used a descriptive statistic test to analyze the data from the response questionnaire items 1 to 15. Then, the obtained M score was transformed into Swanson's M% categorization. Table 8 shows the biology preservice teachers' responses after participating in the project-based learning using AI-assisted tools to develop e-worksheets.

Table 8

Biology Preservice Responses on AI-Integrated Project-Based Learning Model

Items	N	SD	M	M%	Q
I understand how to make student e-worksheets easily.	30	.234	4.82	96.40	Q4
I experience more autonomous learning when developing the e-worksheet.	30	.446	4.71	94.20	Q4
I know several AI-assisted tools to support the making of e-worksheets.	30	.327	4.73	94.60	Q4

Through the project-based learning model, I can apply several AI-assisted tools collaboratively to make good content e-worksheets.	30	.452	4.46	89.20	Q4
I also can use several AI-assisted tools to create more interesting designs for the e-worksheet.	30	.163	4.92	98.40	Q4
I agree that AI-assisted tools should be integrated into every biology learning process because they provide significant assistance.	30	.178	4.90	98	Q4
Even the AI-assisted tools can provide any information, I am sure that humans are still required to plan the project.	30	.210	4.91	98.20	Q4
I can improve my learning performance, especially in coping with developing biology e-worksheets.	30	.274	4.82	96.40	Q4
I recommend using AI-assisted tools to help teachers or students accomplish their tasks.	30	.245	4.87	97.40	Q4
On the other hand, some innovative learning strategies using AI-assisted tools must be further developed.	30	.265	4.80	96	Q4

Table 8 explains that the biology preservice teachers responded positively to all given items. They mostly understood how to use AI-assisted tools to help them create e-worksheets. They also believed that, even though AI-assisted tools were necessary, they still needed to use their human intelligence to create a good e-worksheet plan. In addition, they also recommended the use of project-based learning using AI-assisted tools to help preservice teachers practice creating student e-worksheets. Some preservice teachers conveyed their eagerness for learning through the following interview snippets.

"I am so happy that AI tools can help me accomplish the e-worksheet assignment. I can use ChatGPT to obtain more materials and relevant resources. So, the contents of my e-worksheet are complete and relevant." (S21, snippet 1)

S21 confirmed that project-based learning using AI-assisted tools created more autonomous learning since she could accomplish the task quickly. She could use different AI-assisted tools to gain different data and functions. Snippet 1 confirmed that S21 experienced a good learning process and was interested in using AI-assisted tools during the project-based learning model. In addition, S09 added that such a learning model made him more skillful in making student worksheets because the AI tools offered complete information, references, and preferences.

"The learning process using AI-assisted tools is beneficial. It promotes the ease of making a learning media or student worksheet and lets us use our brains to decide what content is relevant to the product we want to make." (S09, snippet 2)

S09 confirmed that project-based learning using AI-assisted tools could help him better understand how to develop good e-worksheets. He also mentioned the opportunity to practice critical thinking skills when developing the e-worksheets assisted by AI tools. He believed that the AI tools gave more options for the given prompts, but preservice teachers themselves became the ones who could determine how the content or the design would look.

DISCUSSION

This study involved the learning process using project-based learning (PBL) with AI-assisted tools to develop e-worksheets on Biology topics. The undertaken project-based learning involved the introduction of several AI-assisted tools, such as Canva, Google Translate, Gemini AI, QR Code Generator, Copilot AI, AI Image Generator, Liveworksheets, Assemblr Studi, and ChatGPT.

The intention of introducing these AI-assisted tools was to give biology preservice teachers new knowledge about AI tools that could be used to assist their learning process [1]. Introducing AI-assisted tools in learning could increase interactivity and personalize the learning experience so students could learn at their own pace and style [26]. Additionally, these tools helped teachers analyze student progress in real-time, enabling faster and more effective interventions. This technology allows students to access more varied learning resources, enriching their knowledge and skills [27]. Many studies confirmed the importance of this introduction with similar rationales to the present study and many studies also confirmed that AI-assisted tools can increase students' learning performance [28]. Those studies also depicted that knowing each AI-assisted tool was vital to avoid misuse. Thus, the learning steps in the undertaken PBL were justifiable.

In addition, the PBL model implemented in the present study effectively improved biology preservice teachers' ability to develop e-worksheets. AI can significantly improve student learning outcomes by providing fast, accurate feedback [29]. AI tools can analyze each student's learning style, allowing for more precise and effective adjustments to teaching materials [30]. Additionally, AI can help students identify their strengths and weaknesses so they can focus on areas that need improvement. By utilizing AI, students can also develop learning media products that are more innovative and interesting [31]. For example, AI tools can help them design interactive content, such as quizzes and simulations, that supports a deep understanding of concepts.

Additionally, students can use AI to conduct research and find relevant references more efficiently [32]. With all these advantages, students learn better and are ready to contribute to creating more compelling educational solutions in the future. Therefore, the immersion of AI-assisted tools in the PBL process to develop e-worksheets on biology topics was significant.

Many biology preservice teachers involved in the study responded positively to implementing the AI-integrated PBL model. They mostly agreed that AI-assisted tools could be brought into the classroom learning process. Of course, this response was confirmed by many prior studies, which stated that the current learning process could benefit AI tools as learning assistance [33; 34]. This study also found that most biology preservice teachers argued that exposure to human intelligence should also be promoted in AI-integrated teaching. Many studies also highlighted this importance by endorsing human-AI collaborative learning [35; 36]. Using human-AI collaborative learning was critical to creating a more inclusive and effective learning environment. This collaboration allowed students to leverage the power of AI in data analysis and material customization while maintaining the essential human touch in learning [37]. By combining human creative and empathetic abilities, students could develop the social and emotional skills needed in the world of work. In addition, this collaboration could increase student motivation by providing a more dynamic and interactive learning experience [38]. AI can help identify students' interests and talents, providing appropriate recommendations for further development [39]. This approach also allowed teachers to focus on effectively mentoring students. Thus, human-AI collaborative learning improved academic results and prepared students to face future challenges better.

Project-based learning (PBL) with AI-assisted tools in biology learning was critical for improving comprehension of complicated subjects. Project-based learning (PBL) in biology education can enhance students' skills such as creative thinking, innovation, the ability to conduct observations, evaluate projects well, and analyze the value of the project activities [40]. PBL allowed students to participate directly in real-world tasks, such as creating student workbooks. AI-assisted tools could assist students in collecting and analyzing biological data, making the learning process more participatory [16]. Students might readily find correct and up-to-date information using AI, boosting the quality of their work. AI tools also gave students quick feedback as they worked on projects, allowing them to tweak and improve their efforts [41]. PBL also promoted teamwork; with AI, students could interact more successfully via digital platforms, facilitating communication [42].

Furthermore, using AI in PBL allowed students to improve their critical and creative thinking skills by designing and organizing intriguing projects. Developing project-based student worksheets could also make biology material more straightforward and engaging. This technique improved students' grasp of biology principles and prepared them to handle real-world difficulties with applicable abilities. Thus, integrating PBL with AI-assisted technologies was an outstanding technique for increasing the quality of biology learning.

CONCLUSION

This study concludes that project-based learning (PBL) using AI-assisted tools has been proven effective in improving biology preservice teachers' ability to develop e-worksheets. All subskills in developing e-worksheets, such as content, design, functionality, accessibility, and technicality, have improved from the conventional to the undertaken PBL model using AI-assisted tools. The preservice teachers also responded positively after conducting the PBL model using AI-assisted tools. They also recommended using AI-integrated PBL to enhance the ability of preservice teachers to create learning media or assessments. They also state that human-AI collaborative learning must encourage natural human cognitive skills and avoid the students' dependence on AI-assisted tools. In this case, AI-assisted tools act as learning assistants, not to dominate the learning process and lose the essence of educating humans. Since this study is only limited to the context of Indonesian biology preservice teachers, the results of the present study might be used as references to involve AI-assisted tools in biology education, especially in teacher education or training programs. The biology topics involved in the e-worksheets are also limited to the biology topics existing in the higher secondary school curricula; thus, future research could investigate similar topics at other education levels. Moreover, forthcoming research can also use more rigorous experimental research that could portray the actual effects of the designed instructions on students' ability to use AI-assisted tools to accomplish their work.

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Appendix 1

Scoring Rubric

Aspect	Scoring Criteria
Content	1 = the material is not complete, not clear, and irrelevant to the topic; the instruction is ambiguous and difficult to understand; and the content does not promote reflective thinking. 2 = the material is fairly complete, clear, and relevant; the instruction is mostly clear and easy to understand but some are not; and the content rarely promotes reflective thinking. 3 = the material is complete, clear, and relevant; the instruction is clear and easy to understand; and the content somehow promotes reflective thinking. 4 = the material is totally complete, clear, and relevant to the topic of worksheet; all instructions are drawn clearly without ambiguities; and the content always promotes reflective thinking.
Design	1 = the cover design is not interesting; the sequence of worksheets is not good; the page designs are not attractive; and the overall visualization was disturbing. 2 = the cover design is fairly interesting; the sequence of worksheets is fairly good; the page designs are fairly attractive; and the overall visualization was just okay. 3 = the cover design is interesting; the sequence of worksheets is good; the page design was attractive; and the overall visualization was okay. 4 = the cover design is very interesting; the sequence of worksheets is perfect; the page design was very attractive; and the overall visualization was very eye-catching.
Functionality	1 = the worksheet does not promote autonomous learning; there is no exposure for students to review the materials that had been learned; there is no reflective thinking exposures; and, there is no measurement of student's material comprehension. 2 = the worksheet fairly promotes autonomous learning; there is a few exposures for students to review the materials that had been learned; there is seldom reflective thinking exposures; and, there is an inadequate measurement of student's material comprehension. 3 = the worksheet promotes autonomous learning; there is exposure for students to review the materials that had been learned; there is often reflective thinking exposures; and, there is adequate measurement of student's material comprehension. 4 = the worksheet totally promotes autonomous learning; there are exposures for students to review the materials that had been learned; there is always reflective thinking exposures; and, there is very adequate measurement of student's material comprehension.
Accessibility	1 = the worksheet is not easy to access. 2 = the worksheet is fairly easy to access. 3 = the worksheet is easy to access. 4 = the worksheet is very easy to access.
Technicality	1 = the worksheet is not easy to use because of complicated hardware and software required. 2 = the worksheet is fairly easy to use because of some hardware and software required. 3 = the worksheet is easy to use because of simple hardware and software required. 4 = the worksheet is very easy to use because of limited and familiar hardware and software required.

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