
Project-based digital portfolio: Biology assessment and learning innovation to improve student competency

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Abstract

This study aims to develop and evaluate the effectiveness of a project-based digital portfolio, BioPorta, as an assessment and learning medium in the Medicinal Plants course for biology students. The research employed a research and development (R&D) approach using the ADDIE model, which includes analysis, design, development, implementation, and evaluation stages. The product was validated by media and material experts, achieving high validity scores of 86.06% and 94%, respectively. Practical testing showed positive results, with scores of 90% from lecturers, 77.06% from small group trials, and 86.18% from field tests. The effectiveness test using N-gain analysis indicated a significant improvement in student learning outcomes, with a score of 0.805 in the experimental class compared to 0.225 in the control class. These findings demonstrate that BioPorta is a valid, practical, and effective tool for enhancing student competence, engagement, and learning outcomes through project-based digital learning.

Keywords

Authentic assessment, digital portfolio, project-based learning, student competence, technology integration

Article History

Received 26 November 2025
Accepted 11 June 2026

How to Cite

Gusfarenie, D., Nuraida, N., & Suraida, S. (2026). Project digital portfolio: Biology assessment and learning innovation to improve student competency. *Indonesian Research Journal in Education | IRJE |*, 10(2), 1107-1121.
<https://doi.org/10.22437/irje.v10i2.50239>

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Introduction

Education in the 21st century requires innovative learning approaches that integrate technology, critical thinking, and authentic assessment to improve student competence. In higher education, particularly in biology education, learning is expected not only to deliver theoretical knowledge but also to develop students' practical skills, problem-solving abilities, and reflective thinking. Therefore, the integration of digital technology in learning and assessment has become increasingly important to support these competencies.

One emerging approach in modern education is the use of digital portfolios. Digital portfolios allow students to document, reflect on, and showcase their learning processes and achievements in a structured and continuous manner. Compared to conventional assessment methods, digital portfolios provide more comprehensive evidence of student learning by emphasizing both the learning process and outcomes. In addition, digital portfolios encourage student autonomy, self-reflection, and active engagement in the learning process.

Alongside digital portfolios, project-based learning (PjBL) has been widely recognized as an effective instructional approach for enhancing student competence (Thomas, 2000). PjBL emphasizes active learning through real-world problem-solving activities, enabling students to apply knowledge in meaningful contexts. Previous studies have indicated that PjBL can improve critical thinking, collaboration, and creativity, which are essential skills in contemporary education (Lorenzo & Ittelson, 2005). However, implementing PjBL often requires appropriate assessment tools that capture the complexity of student learning processes, such as rubrics that evaluate both individual contributions and group dynamics.

Despite the growing interest in digital portfolios and PjBL, existing studies tend to examine these approaches separately. Research focusing on digital portfolios often emphasizes their role in assessment, while studies on PjBL mainly highlight learning processes and student engagement. Limited research has explored the integration of digital portfolios and project-based learning within a single platform, particularly in the context of higher education biology courses. This gap indicates the need for an innovative learning and assessment system that combines both approaches to support the comprehensive development of students' competence.

In the context of the Medicinal Plants course, students are required to understand not only theoretical concepts but also practical applications related to plant utilization and processing. However, preliminary observations indicate that current learning and assessment practices remain dominated by conventional methods, limiting students' opportunities to engage in active learning and reflective assessment, which are essential for applying theoretical concepts to real-world scenarios in the Medicinal Plants course. As a result, student competence development has not been optimal.

To address this issue, this study develops a project-based digital portfolio application called BioPorta. This application is designed to facilitate learning and assessment by integrating PjBL (project-based learning) activities with digital portfolio features, allowing students to document their projects, reflect on their learning experiences, and receive feedback from lecturers. By combining these approaches, BioPorta is expected to provide a more effective and meaningful learning experience.

Therefore, this study aims to develop and evaluate the validity, practicality, and effectiveness of BioPorta as a project-based digital portfolio in improving student competence in biology learning. The findings of this study are expected to contribute to the development of innovative learning and assessment strategies in higher education.

Literature Review

Digital portfolio in learning and assessment

Digital portfolios have emerged as an innovative assessment tool that supports student-centered learning and continuous evaluation. A digital portfolio is a collection of students' work that demonstrates their learning progress, achievements, and reflections over time. Unlike traditional assessment methods, which often focus solely on outcomes, digital portfolios emphasize both the learning process and product, providing a more comprehensive representation of student competence.

Previous studies highlight that digital portfolios enhance students' self-regulation, reflective thinking, and engagement in learning activities. According to Barrett (2011), digital portfolios promote deeper learning by encouraging students to document and reflect on their experiences. Similarly, Lorenzo and Ittelson (2005) argue that digital portfolios facilitate authentic assessment by allowing students to demonstrate their competencies in real-world contexts. However, despite these advantages, the implementation of digital portfolios in higher education is often limited by the lack of integrated platforms that effectively support both learning and assessment.

In addition, digital portfolios play a crucial role in fostering lifelong learning skills. By engaging in continuous documentation and reflection, students develop the ability to monitor their own progress and identify areas for improvement. This process aligns with constructivist learning theory, which emphasizes active knowledge construction through experience and reflection. Nevertheless, challenges such as limited technological infrastructure, low digital literacy, and a lack of institutional support may hinder the effective adoption of digital portfolios, which are essential for facilitating student engagement and self-assessment in project-based learning environments. Therefore, there is a need for user-friendly and structured digital portfolio systems that can be easily integrated into teaching and learning practices.

Project-based learning (PjBL) and student competence

Project-based learning (PjBL) is a student-centered instructional approach that emphasizes learning through real-world projects and problem-solving activities. This approach enables students to actively construct knowledge, develop critical thinking skills, and enhance collaboration. In biology education, PjBL is particularly relevant as it allows students to apply theoretical concepts in practical contexts.

Research has consistently shown that PjBL significantly improves student competence. Thomas (2000) states that PjBL promotes meaningful learning by engaging students in complex tasks that require inquiry and problem-solving. Furthermore, Bell (2010) highlights

that PjBL enhances creativity, communication, and collaboration skills, which are essential for 21st century learning. Nevertheless, one of the main challenges in implementing PjBL lies in the assessment process, as traditional evaluation methods are often insufficient to capture the complexity of student learning outcomes, making it difficult to accurately measure students' understanding and skills in real-world applications.

Furthermore, the effectiveness of PjBL is closely related to the availability of appropriate instructional support and assessment strategies. Without proper guidance and structured evaluation tools, students may struggle to achieve the intended learning outcomes. In this context, integrating reflective activities and continuous feedback is essential to ensure that students not only complete projects but also internalize the learning process. Therefore, combining PjBL with suitable assessment tools can enhance both the learning experience and the measurement of student competence.

Integration of digital portfolio and project-based learning

The integration of digital portfolios with project-based learning offers a promising approach to addressing the limitations of conventional assessment methods. By combining these two approaches, educators can create a learning environment that supports both active learning and authentic assessment. Digital portfolios can serve as a platform for documenting project activities, reflecting on learning experiences, and providing continuous feedback.

Several studies suggest that integrating digital portfolios with PjBL enhances both learning outcomes and assessment quality. For instance, [Cheng and Chau \(2013\)](#) found that students who used e-portfolios in project-based environments demonstrated higher levels of engagement and reflective thinking. Similarly, [Yancey \(2009\)](#) emphasizes that portfolios support process-oriented assessment, which aligns well with the principles of PjBL. However, research on the implementation of integrated systems, particularly in biology education, remains limited, which hinders the ability to fully understand the effectiveness of these approaches in enhancing student learning outcomes.

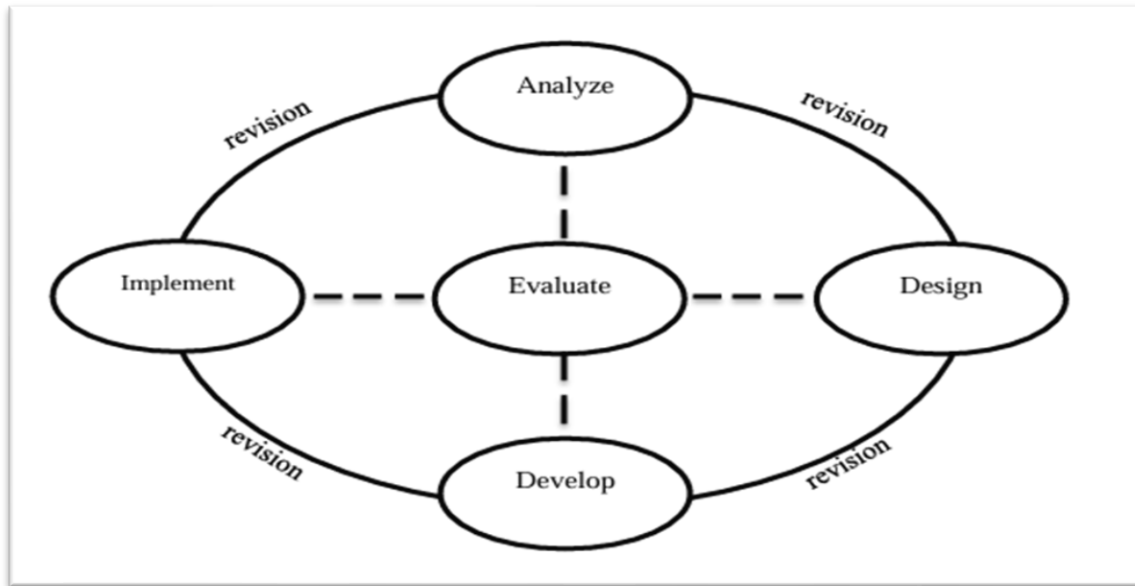
Moreover, integrating digital portfolios and PjBL supports a more holistic evaluation of student competence by capturing cognitive, affective, and psychomotor domains simultaneously. This approach allows educators to assess not only what students know but also how they apply knowledge and reflect on their learning experiences. Despite its potential, the development of integrated platforms that effectively combine these approaches is still limited, particularly in terms of accessibility, user-friendliness, and the ability to track student progress over time. Therefore, the development of a project-based digital portfolio, such as BioPorta, addresses this gap by providing an integrated system that enhances learning, assessment, and reflection within a unified environment.

Methodology

This research uses the research and development method. This development research employs the ADDIE model as its framework. ADDIE stands for the process stages: Analyze, Design, Develop, Implement, and Evaluate. The research and development model is a research method used to develop a specific product and assess its effectiveness. Research and

development serve to validate and develop products (Scott et al., 2020). To create certain products, useful research is conducted within the community, so testing is needed to validate the product, and ensure it meets the needs and expectations of potential users. The product developed is a digital-based portfolio. The development procedure for this research consists of several stages, namely Analyze, Design, Develop, Implementation, and Evaluate, which are described based on the following flow:

Figure 1. *ADDIE development procedure*



The first stage, analysis, begins by identifying students' needs, competencies, and characteristics, so that the development of project-based digital portfolios in the Medicinal Plants course can take place effectively and in context. The needs analysis shows the need for active learning innovations that replace conventional lecture and exam methods. A digital portfolio is needed to support project-based learning, facilitate authentic assessments, monitor achievement, and provide continuous feedback through digital technology. Competency analysis indicates that students remain weak in applying concepts and practical skills. Through project-based learning and digital portfolios, students can hone analytical and plant identification skills as well as develop reflective attitudes and professional responsibility. Analysis of students' characteristics shows that they have a strong biological foundation, but their understanding of medicinal plants varies. Their learning styles are diverse, with visual and practical tendencies, and they have quite excellent technological capabilities. Digital portfolios are considered effective in adjusting learning styles, improving digital literacy, and supporting collaboration in projects. By understanding the various needs, competencies, and characteristics of these students, the development of a project-based digital portfolio in the Medicinal Plants course is expected to create a more active, contextual, and reflective learning process. This learning model not only strengthens understanding of concepts and practical

skills but also develops professional attitudes, responsibilities, and students' collaborative abilities as prospective biology educators who are competent and of integrity.

The second stage is the design stage, starting with the creation of a storyboard as a visual guideline for digital portfolio development for project-based assessment and learning. The storyboard provides an overview of the application's main page, including login, registration, adding materials and exams, announcements, profile settings, question data (multiple-choice and essay), student access, assignments, materials, and user profile pages. Each page contains a description of the components required to make it easier for users. Furthermore, product specifications are determined through analysis of needs and development goals, including user feedback, educational requirements, and technological capabilities, to ensure the application effectively meets the needs of both students and lecturers. This product aims to help students and lecturers with the process of collecting and evaluating assignments and can be accessed flexibly on any device with an internet connection. It is also available on the Play Store. Finally, the digital portfolio prototype, developed by IT experts based on a storyboard design, is web-based and supports the documentation and systematic organization of student work. Its advantages include enhancing the effectiveness of reflective learning, developing critical and creative thinking skills, building personal branding, expanding career opportunities, facilitating interactive feedback from lecturers, and strengthening students' independence and readiness to enter the professional world.

The third stage is the development stage, which is the process of turning the design into a real product in the form of a digital portfolio for 5th-semester biology students. This product is developed based on design specifications compiled and validated by material, media, and language experts to ensure its feasibility as a project-based learning and assessment medium. The validation results are used to correct parts of the application that fail to meet the valid criteria until they do. After the revision is completed and the product is declared feasible, a small-group trial is conducted with 10 students with diverse abilities, using observation and interviews, to assess the product's advantages and disadvantages before it is widely applied. The analysis carried out by the validator is then calculated based on predetermined criteria.

Table 1. *Validation assessment criteria*

Grade achievement categories (%)	Validity levels
≥81.5 – 100	Highly valid
≥62.5 – 81.5	Valid
≥43.5 – 62.5	Less valid
≥25 - 43.5	Invalid

The fourth stage is implementation. The implementation stage in this research and development is a step toward applying digital portfolio products developed in actual conditions, namely, in the classroom with students. Digital portfolio products, as a medium for assessment and project-based learning during implementation, serve as proof that they are ready for use after undergoing expert testing. At this stage, the assessment and development media are applied in the 5th semester of the biology study program, using digital portfolio products developed and tested by experts.

The fifth stage is evaluation, which assesses whether the learning system being built is successful and meets initial expectations. The evaluation stage can occur in each of the four stages above. The evaluation that occurs in each of the four stages above is called a formative evaluation because its purpose is to identify revision needs. Evaluation is a process that is carried out to provide value to the learning program. Test the effectiveness of the assessment instrument using an application developed by the researcher. There is an N-gain test. The purpose of the normalized gain test (N-gain score) is to find out how well a method works in the research. The N-gain score is the difference between the posttest and pretest scores. In this study, the n-gain test can be applied because there is a significant difference between the posttest scores of the experimental and control classes, as determined by an independent-samples t-test. Below is the formula for the N-gain test:

$$Gain = \frac{Posttest\ score - Pretest\ score}{Ideal\ score - Pretest\ score}$$

The assessment is categorized according to the criteria listed below.

Table 2. *N-gain screening criteria*

N-gain values	Categories
$g > 0.7$	High
$0.3 \leq g \leq 0.7$	Medium
$g < 0.3$	Low

Results

Analysis

Based on interviews with lecturers and student questionnaires in the Medicinal Plants course, it was found that there was a need for digital media to facilitate the collection of assignments and projects, while increasing student motivation and involvement. Lecturers want a digital portfolio system that is structured, practical, and supports rubric-based assessment, while students expect interactive media that is easy to use and supports two-way communication. The results of the competency analysis show that students understand the basic concept of medicinal plants but are still weak at relating theory to practice and require improvement in independence, self-reflection, and creativity. Conventional portfolios are considered suboptimal, so the development of digital portfolios is expected to enable the comprehensive recording, assessment, and development of student competencies. Based on the characteristics of Tadris biology students who have a strong biology foundation, varied learning motivations, and visual and kinesthetic learning tendencies, project-based digital portfolios are seen as relevant to accommodate differences in learning styles, improve digital literacy, strengthen collaboration skills, and support meaningful interactive learning.

Design

The design stage involved creating an initial prototype of the product in the form of a digital portfolio called BioPorta (Digital Portfolio Biology), developed using the PHP 8.2.12 web framework and the MariaDB database. This application is designed as a medium for assessment and project-based learning to improve the competence of biology students. BioPorta's key features include login and registration pages for user authentication, material management, announcements, exam pages (both multiple-choice and essay), and dedicated pages for lecturers and students. Lecturers can add or update materials, manage assignments and exams, and manage personal profiles, while students can access textbooks, submit project assignments, take exams, and update personal data. All student project assignments are collected digitally through this application, which can be accessed directly via the web without additional installation, thereby supporting a more efficient, interactive, and well-documented learning and assessment process.

Development

At this stage, the product is developed according to the prepared plan. Develop digital portfolios as a medium for assessment and project-based learning to improve student competence. After developing the product, material and media validators assess its feasibility and suitability during the validation stage. The assessment conducted by the material validator covers several aspects to ensure that the developed media is worth using. The assessment is carried out by media and material validators as follows.

Table 3. *Results of media and material validator assessments*

Experts	Scores	Total Scores	Percentages	Criterion
Media	142	165	86.06%	Highly Valid
Material	47	50	94%	Highly Valid

Table 3 presents the overall validation results. The digital portfolio product was classified as "very feasible" based on validation results from media experts, with an 86.06% score. Similarly, the validation results from the subject matter experts are classified as "very feasible" with a score percentage of 94%. The evaluator stated that the digital portfolio, as a medium for assessment and learning, is highly feasible for educational use. The suggestions and feedback from validators are used to improve the development of the digital portfolio, ensuring that it meets educational standards and effectively supports student learning outcomes. The following digital portfolio design, displayed as a medium for assessment and project-based learning, has undergone validation and revision based on input from media and materials expert lecturers and is ready for implementation.

Figure 2. Login page view

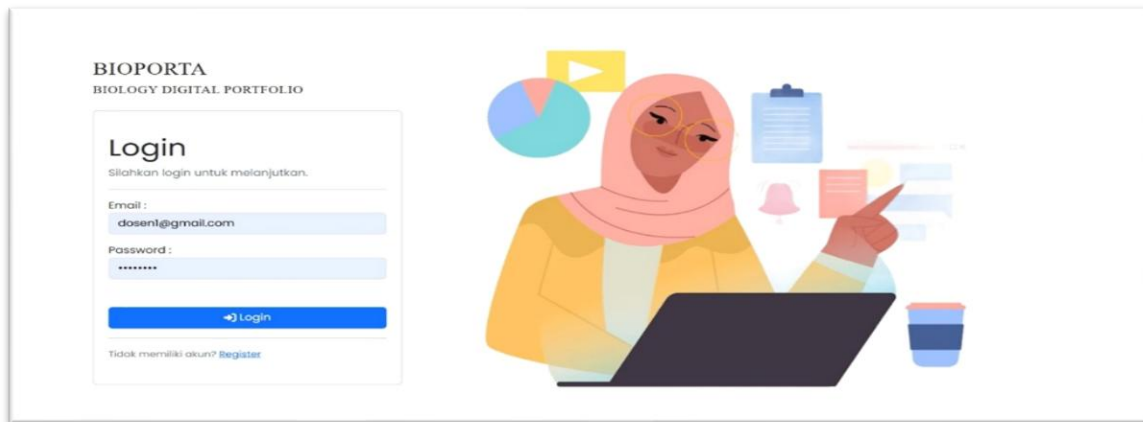


Figure 3. Dashboard view

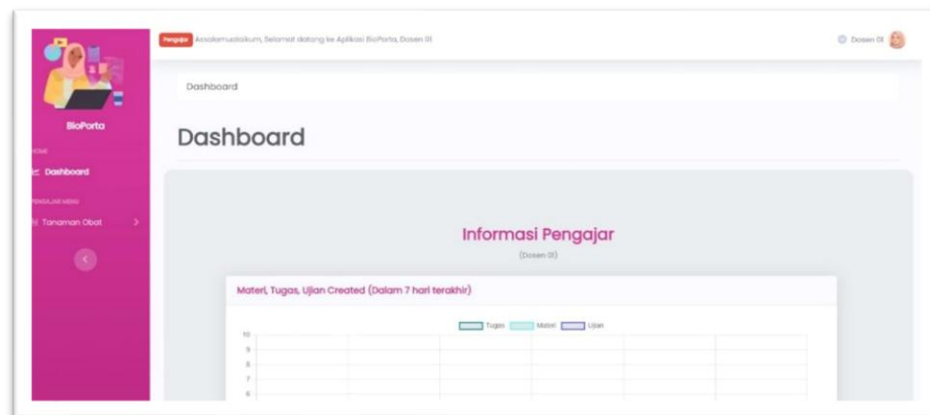


Figure 4. Course menu display

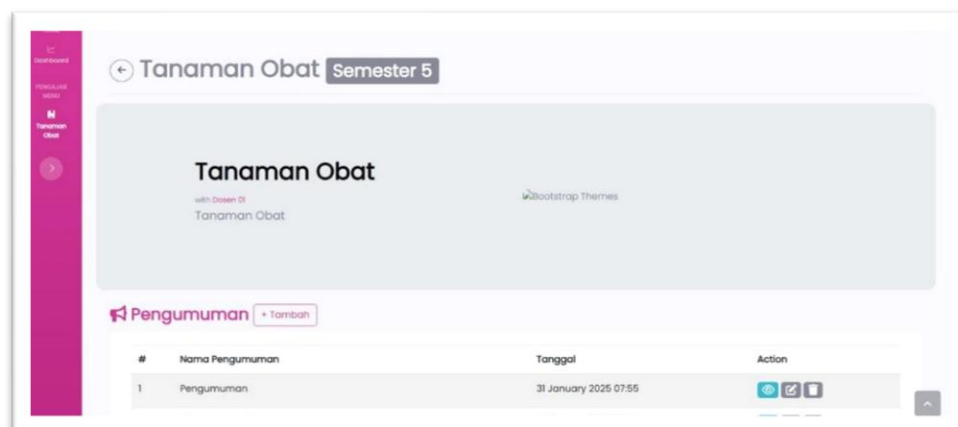


Figure 5. *Material, assignments and exams*

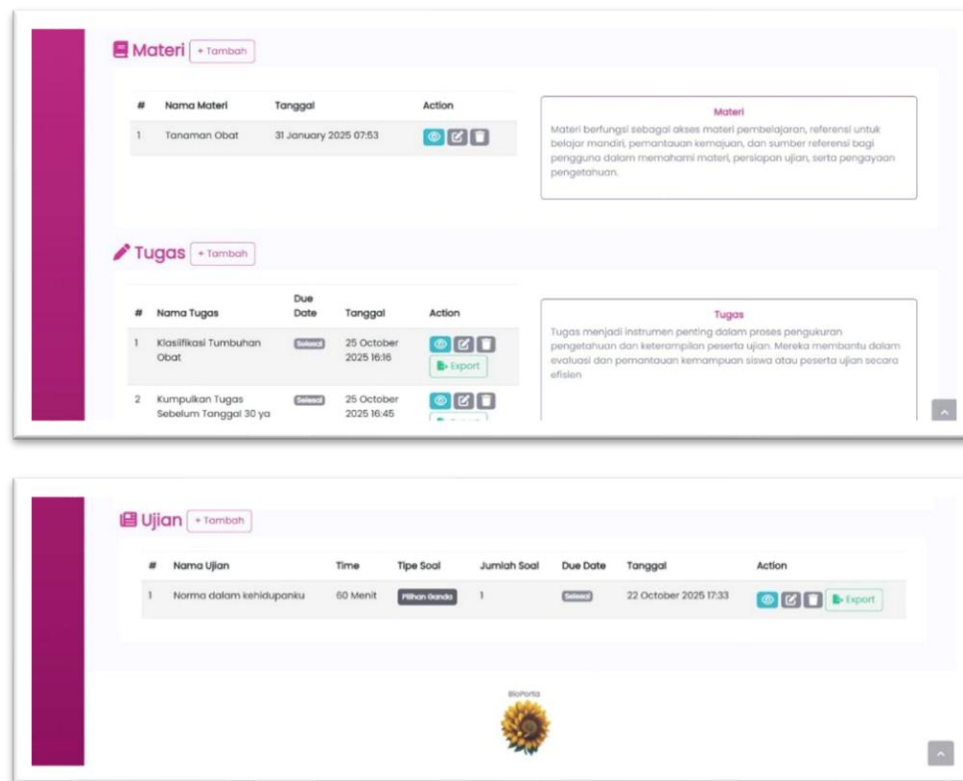
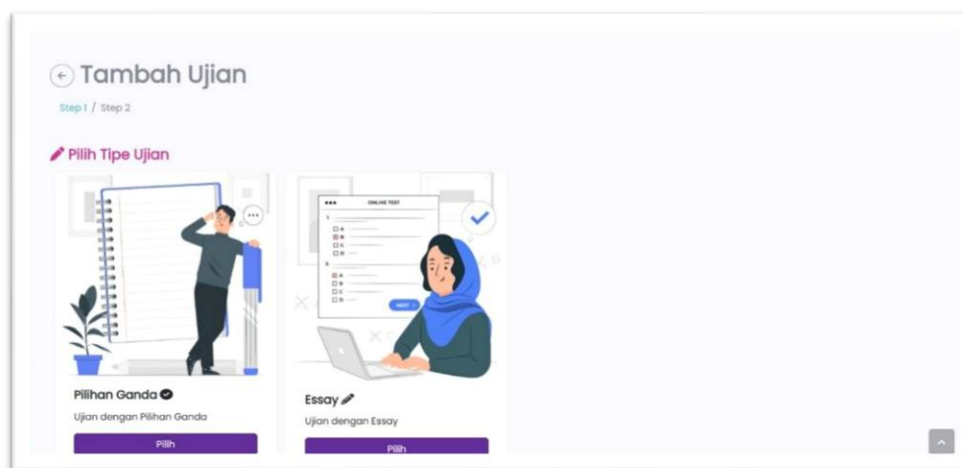


Figure 6. *Exam questions (multiple choice and essay)*



The lecturer's practicality test was carried out on 1 respondent. The purpose of the lecturer's practicality test is to measure the ease of use, clarity, and relevance of learning instruments

from the teacher's perspective. This process involves teachers as respondents who provide assessments based on their experience with the application, the results of the practicality test conducted by lecturers, and the digital portfolio as a medium for assessment and project-based learning, which is assessed as Sangat Praktis with a practicality percentage of 90%. This shows that the instrument has met the ease-of-use and students' interest and motivation criteria for supporting learning through digital portfolio applications as a medium for assessment and project-based learning.

The results of the Student Practicality Test are used to determine the extent to which a product can be used easily, effectively, and usefully by students. This test was carried out in two stages: a small-group trial and a field trial (or large-group trial). The first stage of the trial is a small group trial. The purpose of the small-group trial was to obtain empirical evidence on a limited digital portfolio. The initial product trial was conducted in class B, Semester 5, with 6 students. The results of 6 respondents, across all aspects of the feasible category, showed an average practicality test score of 77.06%. In addition, students who were tested in the initial trial provided positive responses or responses related to the use of digital portfolio applications as a medium for assessment and project-based learning. The results of a large-group trial with 15 5th-semester students in the Medicinal Plants course of the Tadris biology study program, to determine the practicality of the digital portfolio as a medium for assessment and project-based learning, were. The student analysis, comprising 15 respondents, yielded an overall average of 86.18% in the Very Practical category. The following are the results of the practicality test of lecturers and students:

Table 4. *Results of lecturer and student responses*

Responses	Percentage	Criteria
Small Scale Response	77.06%	Practical
Large-Scale Response	86.18%	Very Practical
Lecturer's Response	90%	Very Practical

Implementation

After the validation process carried out by media and material experts and the implementation of improvements, the next step is to test this digital portfolio with 15 students in the 5th-semester biology class. At this stage, the assessment instrument, using the digital portfolio application, is applied directly to two groups of classes: the experimental class and the control class. The application is carried out in biology learning with medicinal plant material in the biology study program of UIN STS Jambi, semester 5.

The effectiveness of the assessment instrument, using a digital portfolio application as a medium for assessment and project-based learning to improve student competence in biology learning, was evaluated in experimental and control classes through pretest and posttest. Then the results were analyzed using an N-gain test to compare improvements in student competence (learning outcomes) between the experimental and control classes. From the results of the calculation of the value of the competency results (learning outcomes) of the experimental class with N-gain in the range of >0.7 , which is 0.805, in the high category, it shows that the experimental class showed a significant increase in understanding after the

learning treatment related to the material of ethical principles in the clinical study of herbal ingredients.

Based on the N-gain test results from the experimental and control classes, the overall results were summarized.

Table 5. *Overall result n-gain value*

N-gain results	Classes	
	Experimental	Control
Average	0.805	0.225

Based on the results of the N-gain test, the average N-gain value of the experimental class was 0.805 (very high category), while the control class was only 0.225 (low category). This shows that the digital portfolio application has been effective in improving students' competence in the Medicinal Plants course at the biology study program of UIN STS Jambi, semester 5. Thus, the alternative hypothesis (H_a) was accepted, and the null hypothesis (H_0) was rejected, indicating that the use of digital portfolios as a medium of assessment and project-based learning is more effective than manual assessment in improving the learning outcomes of 5th-semester students.

Discussion

This study discusses the development of BioPorta's digital portfolio as a project-based assessment and learning medium in the Medicinal Plants course, focusing on material on ethical principles, clinical studies of herbal ingredients, simplicia, and the standardization of plant extracts. Development was carried out using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model, which produces effective and suitable digital learning media.

Digital portfolios are developed based on the needs of lecturers and students: lecturers want ease of project collection and assessment, while students need interactive media that support independent and collaborative learning. These findings are in line with studies showing that digital portfolios increase motivation, critical thinking, and learning engagement (Yuliaturiside et al., 2025). Competency analysis indicates that students understand basic concepts but have difficulty with reflection and applying them in practice. Transformation to a digital portfolio is an important solution because it facilitates academic reflection and effective collaboration. Digital portfolios have also been shown to improve reflection and self-learning skills, particularly by allowing students to document their learning processes and receive feedback from peers and instructors. The characteristics of students who tend to be visual and kinesthetic are accommodated through web-based platforms that support multimedia, collaboration, and digital literacy, in accordance with the findings that digital portfolios strengthen technology and collaboration competencies. BioPorta is developed using PHP and MariaDB with comprehensive features for task, exam, and material management. Validation of media and material experts showed high technical and pedagogical feasibility (86.06% and 94%), supporting curriculum standards and consistency of learning

content. BioPorta documented learning outcomes in text, images, and videos, enabling real-time evaluation and quick feedback, in line with the theory that digital portfolios reinforce authentic and reflective learning (Ayaz & Gök, 2023; Lu, 2021; Mogas et al., 2023; Yuliaturoside et al., 2025).

The results of the practicality test showed high scores: small group 77.06% (practical) and field test 86.18% (very practical). Students assessed the BioPorta feature as straightforward, interactive, and supportive of understanding the material, as well as increasing learning motivation (Mantara et al., 2021). This digital portfolio has proven to be a valid and practical medium for project-based learning, supporting active participation, critical thinking, and student reflection. Empirically, the data showed a significant improvement in learning outcomes with an average N-Gain of 0.805 (high category > 0.7) in the experimental class, compared to 0.225 (low-medium category < 0.3) in the control class. Digital portfolios have been shown to increase students' understanding of the material and their active involvement in technology learning (Domene-Martos et al., 2021; Sari, 2025). This success is attributed to digital portfolios' ability to provide a reflective, collaborative, and contextual learning experience focused on medicinal plants (Meli et al., 2024).

Digital portfolios also enhance learning effectiveness, strengthen concept mastery, and increase motivation by allowing students to track their progress, receive feedback from peers and instructors, and engage in self-assessment throughout their learning journey. This application is recommended for learning that demands scientific practice and reflection, such as the study of the biology of medicinal plants. Continuous evaluation and feature development are still necessary to keep the app relevant and easy to use, especially as user needs and educational technologies evolve over time. Thus, the research confirms that the implementation of BioPorta's digital portfolio significantly improves student competence through authentic, interactive, and technology-based, project-based learning in the biology study program of UIN STS Jambi.

Conclusion

This research develops a project-based digital portfolio for the Medicinal Plants course that has proven valid, practical, and effective in improving the competence of Tadris Biology students. The web-based application, BioPorta, is designed to make it easier for lecturers to assess and collect assignments while helping students learn interactively through assignment management, exams, materials, user profiles, and announcements. The validation results showed very high validity, namely 86.06% among media experts and 94% among material experts, indicating that the content, appearance, and technicality of the application are relevant to the needs of digital learning and the biology curriculum. In terms of practicality, the scores obtained were 90% for lecturers, 77.06% for small-group tests, and 86.18% for field tests, indicating that this application is easy to use, efficient, and attractive to students. The results of the N-gain test also showed a significant increase in the experimental class (0.805, high category) compared with the control class (0.225, low category). These findings show that the use of digital portfolios can improve student understanding, engagement, and learning outcomes more effectively than conventional methods. Thus, BioPorta is suitable for use as

an innovative, relevant learning and project-based assessment medium that supports the development of students' cognitive, psychomotor, and affective competencies.

Disclosure Statement

No potential conflict of interest was reported by the authors.

Acknowledgments

I would like to express my gratitude to the State Islamic University of Sulthan Thaha Saifuddin Jambi through the Institute for Research and Community Service (LPPM) for providing support and funding for this research. This assistance is very meaningful in the smooth implementation and completion of this research.

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