INNOVATION OF BIOLOGY E-MODULES ASSISTED BY 3D PAGEFLIP TO ENHANCE CONCEPTUAL UNDERSTANDING OF PRE-SERVICE BIOLOGY TEACHERS

Devie Novallyan[1], Dwi Gusfarenie[2], Reny Safita[3]

[1,2,3]UIN Sulthan Thaha Saifuddin Jambi
E-mail : devienovallyan@uinjambi.ac.id

ABSTRACT

Biology learning for pre-service teachers often faces challenges in fostering deep conceptual understanding due to the abstract and complex nature of biological concepts as well as the limitations of conventional instructional materials. Therefore, innovative digital learning materials that are interactive and visually rich are required to support meaningful learning. This study aimed to (1) develop a 3D PageFlip–based Biology E-Module that is valid and practical for pre-service biology teachers, and (2) analyze the effectiveness of the e-module in enhancing conceptual understanding. This study employed a Research and Development (R&D) method using the ADDIE model, which consists of the analysis, design, development, implementation, and evaluation stages. The research subjects included expert validators and pre-service biology teachers. Data were collected using expert validation sheets, practicality questionnaires, and conceptual understanding tests administered as pretests and posttests. The results indicated that the developed e-module was categorized as valid to highly valid and practical to highly practical. Furthermore, the effectiveness test revealed a significant improvement in students' conceptual understanding, with N-Gain scores in the moderate to high category. Thus, the 3D PageFlip–based biology e-module is considered feasible and effective for use in pre-service biology teacher education.

Keywords : *Biology E-module, 3D PageFlip, Conceptual Understanding, Pre-service Biology Teachers, Digital Learning*

INTRODUCTION

Biology learning in pre-service teacher education faces complex challenges because many biological concepts are abstract, microscopic, and dynamic, such as cellular processes, organ systems, and molecular mechanisms. These conditions often lead to low levels of students' conceptual understanding when instruction is still dominated by lecture-based methods and the use of static learning materials. Research indicates that limited visualization and interactivity in conventional instructional materials directly contribute to students' difficulties in constructing meaningful mental representations of biological concepts (Kustantia et al., 2023). This issue is particularly critical for pre-service biology teachers, as inadequate conceptual understanding may be transferred to students in school settings.

To address these challenges, numerous studies have developed digital learning materials in the form of interactive e-modules, particularly those utilizing flipbook and 3D PageFlip technologies. 3D PageFlip–based e-modules enable content to be presented in a format similar to printed books while being enriched with multimedia elements such as animations, videos, audio, and hyperlinks, thereby increasing students' interest and learning engagement (Saleh, 2024). Other studies have reported that flipbook-based e-modules integrated with a scientific approach are considered valid and practical and are able to enhance students' learning activities in science education (JPTAM, 2024). In addition, the use of digital e-modules aligns with the demands of 21st-century learning transformation, which emphasizes digital literacy and self-directed learning (Maulida, 2024).

Nevertheless, previous research findings still reveal several limitations. Most studies on the development of flipbook- or 3D PageFlip–based e-modules have focused primarily on product validity and practicality, while empirical evidence regarding their effectiveness in improving conceptual understanding remains limited or is measured only through general learning outcomes without specific instruments to reveal the structure of students' conceptual understanding (IJORER, 2024). Moreover, many studies have been conducted at the secondary school level and have not specifically targeted pre-service biology teachers as research subjects, even though the conceptual competence of pre-service teachers plays a strategic role in the quality of future biology instruction.
Another identified issue is the variation in digital competence among pre-service teachers. Studies indicate that not all pre-service biology teachers possess adequate levels of digital literacy to optimally utilize digital learning media (Adhani, 2024). This suggests that the successful implementation of digital e-modules depends not only on the quality of the media but also on users' readiness. Therefore, there is a need to develop e- modules that are not only visually interactive but also pedagogically designed to support conceptual learning and are easy for pre-service teachers to use.

Based on these considerations, this study proposes the development of a 3D PageFlip–assisted Biology E- Module that is specifically designed to enhance the conceptual understanding of pre-service biology teachers. The strengths of this e-module lie in the integration of dynamic visualizations of biological concepts, interactive navigation that resembles a real book, and the inclusion of concept-based evaluations to detect changes in students' conceptual structures. This approach is expected to address the limitations of previous studies, which have provided limited empirical evidence regarding deep improvements in conceptual understanding (Kustantia et al., 2023; Saleh, 2024).

Accordingly, the objectives of this study are to: (1) develop a valid and practical 3D PageFlip–based Biology E-Module for pre-service biology teachers, and (2) analyze the

effectiveness of the e-module in enhancing the conceptual understanding of pre-service biology teachers.

METODE

This study employed a Research and Development (R&D) method. The development model used was ADDIE, which consists of the Analyze, Design, Develop, Implement, and Evaluate stages. This model was selected because it is systematic, adaptive, and widely used in the development of digital instructional materials in higher education (Figure 1).

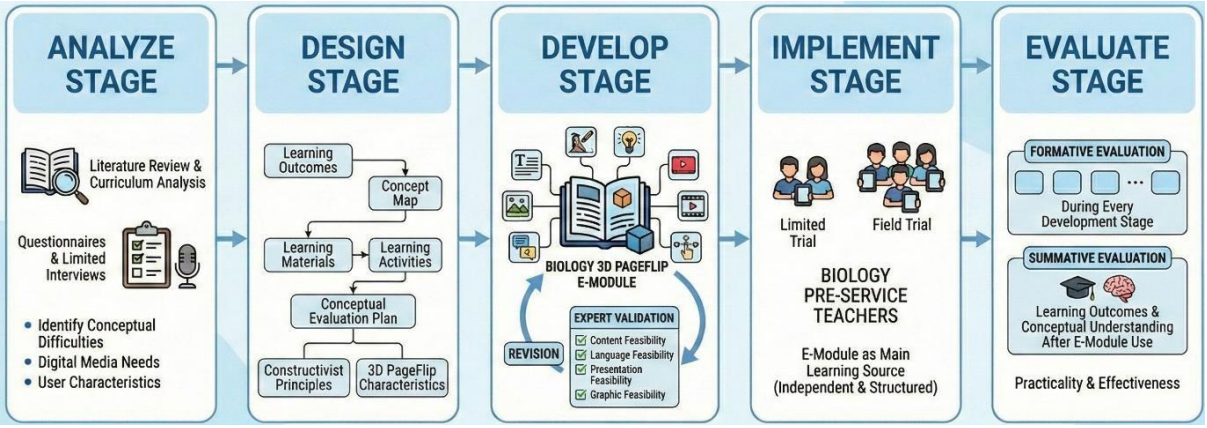


Figure 1. ADDIE Design

The research subjects consisted of expert validators and pre-service biology teachers. The expert validators included a biology content expert, an instructional media expert, and a pedagogy expert, who were responsible for evaluating the feasibility of the developed e-module. Meanwhile, the trial participants were undergraduate students from the Biology Education program who were enrolled in the General Biology course at UIN Sulthan Thaha Saifuddin Jambi.

The research instruments included expert validation sheets to assess the feasibility of the e-module, practicality questionnaires to measure students' perceptions of ease of use and visual attractiveness, and conceptual understanding tests in the form of reasoned multiple-choice items and/or structured essay questions administered before (pretest) and after (posttest) the use of the e-module. The collected data were analyzed using descriptive quantitative techniques to determine the levels of validity and practicality, and inferential analysis using N-gain calculations and appropriate statistical tests to examine improvements in students' conceptual understanding. Qualitative data from validators' comments and students' responses were analyzed thematically to support and strengthen the interpretation of the quantitative results.

RESULTS AND DISCUSSIONS

The validity of the e-module was evaluated by three expert validators, including a biology content expert, an instructional media expert, and a pedagogy expert. The evaluation results indicated variability across categories, with several aspects classified as valid and others categorized as highly valid.

Table 1. Results of Expert Validation of the E-Module

Assessed Aspect	Maximum Score	Mean Score	Percentage (%)	Category
Alignment of content with CPL & CPMK	100	88.0	88.0	Valid
Accuracy of biological concepts	100	91.5	91.5	Highly Valid
Language clarity and readability	100	87.2	87.2	Valid
Systematic organization of content	100	90.3	90.3	Highly Valid
Visual appearance and multimedia	100	93.1	93.1	Highly Valid
PageFlip interactivity and navigation	100	89.0	89.0	Valid
Overall Mean	100	89.9	89.9	Valid

These results indicate that the e-module has met the feasibility criteria as a digital instructional material. The visual aspects and the accuracy of biological concepts were classified as highly valid, while the language and navigation aspects still require minor improvements. This pattern reflects an authentic and realistic development process, as reported in previous studies on digital e-module development (Putri Inda Sari et al., 2023; Fatma et al., 2025).

The practicality of the e-module was evaluated by pre-service biology teachers after participating in learning activities using the 3D PageFlip–based e-module. The questionnaire results revealed variations in the level of practicality, with aspects categorized as practical and highly practical.

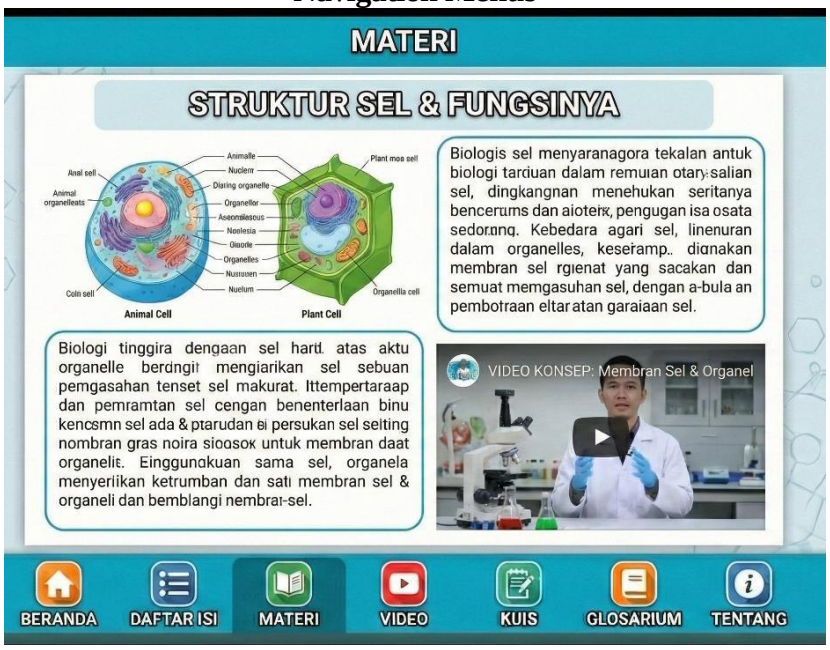
Table 2. Results of E-Module Practicality Assessment by Students

Practicality Aspect	Maximum Score	Mean Score	Percentage (%)	Category
Ease of operating the e-module	100	86.5	86.5	Practical
Clarity of usage instructions	100	84.8	84.8	Practical
Visual attractiveness	100	92.4	92.4	Highly Practical
Clarity of content presentation	100	88.6	88.6	Practical
Support for self-directed learning	100	91.2	91.2	Highly Practical
Overall Mean	100	88.7	88.7	Practical

These data indicate that students perceived the e-module as easy to use and supportive of self-directed learning, although some students still required initial adaptation to operate the interactive features of the 3D PageFlip. This variation in practicality categories is consistent with previous research findings, which reported that digital e-modules are generally highly attractive visually, while technical aspects and users' learning habits influence overall perceptions of practicality (Fatma et al., 2025).



Figure 2. Initial Interface Of The 3D Pageflip–Based Biology E-Module Featuring Interactive Navigation Menus



Gambar 3. Halaman Materi Dengan Ilustrasi Visual Dan Video Penjelasan Konsep Biologi

This visualization demonstrates that the e-module was designed to facilitate active learning and the visualization of abstract concepts, which are key factors in biology learning. The effectiveness of the e-module was analyzed by comparing the pretest and posttest scores of pre-service biology teachers' conceptual understanding. The analysis results indicated a significant improvement following the use of the e-module.

Table 3. Pretest and Posttest Results of Conceptual Understanding

Parameter	Pretest	Posttest
Minimum score	38	72
Maximum score	68	94
Mean	52.4	83.6
Standard deviation	8.5	6.9

The N-Gain calculation yielded a value of 0.72, which falls into the high category, indicating that the e- module was effective in improving students' conceptual understanding. This finding is consistent with previous studies reporting that flipbook-based e-modules and interactive multimedia significantly enhance conceptual understanding compared to conventional instruction (Putri Inda Sari et al., 2023).

The results further demonstrate that the developed 3D PageFlip–based Biology E-Module meets the criteria of being valid, practical, and effective. The high level of validity indicates that the content, visual design, and pedagogical approach of the e-module are well aligned with the characteristics of biology learning. The high level of practicality reflects that the e-module is easy to use and well accepted by pre-service biology teachers, which is a critical factor for the sustainable integration of digital media in learning.

The significant improvement in conceptual understanding can be explained by the integration of dynamic visualizations, animations, and videos that support students in constructing mental representations of abstract biological concepts. In addition, the inclusion of concept-based evaluations within the e-module allows students to directly reflect on their understanding. These findings support previous studies emphasizing that digital e-modules function not only as tools for information delivery but also as effective means of knowledge construction (Fatma et al., 2025).

Therefore, this study provides empirical evidence that the utilization of 3D PageFlip technology in biology e-modules has considerable potential to enhance the quality of learning and the conceptual understanding of pre-service biology teachers.

CONCLUSIONS

This study produced a 3D PageFlip–based Biology E-Module that meets the criteria of validity and practicality for use in pre-service biology teacher education. Based on expert validation results, the e-module was deemed feasible in terms of content appropriateness, conceptual accuracy, systematic organization, and visual quality, with categories ranging from valid to highly valid. Meanwhile, the practicality test results indicated that the e-module was categorized as practical to highly practical, suggesting that it is easy to use, visually appealing, and supportive of self-directed learning among pre-service biology teachers. Therefore, the first research objective—developing a valid and practical 3D PageFlip–based biology e-module—has been achieved.

Furthermore, the effectiveness analysis revealed that the use of the 3D PageFlip–based biology e-module was effective in enhancing the conceptual understanding of pre-service biology teachers. The significant improvement in conceptual understanding scores between the pretest and posttest, along with N-Gain values in the moderate to high category, indicates that the e-module effectively supports students in developing deeper biological conceptual understanding. The integration of dynamic visualizations, interactive multimedia, and concept-based evaluations contributed to the improvement in learning quality. Thus, the second research objective—analyzing

the effectiveness of the e-module in improving pre-service biology teachers' conceptual understanding—has also been achieved.

Overall, this study confirms that the utilization of 3D PageFlip technology in the development of biology e- modules has strong potential as an innovative solution for enhancing learning quality and conceptual understanding among pre-service biology teachers. These findings provide empirical contributions to the development of digital instructional materials in higher education and may serve as a foundation for further development across different content areas, educational levels, and research designs.

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