Jurnal Penelitian dan Pengkajian Ilmu Pendidikan: e-Saintika
https://journal-center.litpam.com/index.php/e-Saintika/index

March 2024 Vol. 8, No. 1
e-ISSN: 2615-6881
pp. 86-101

Development of E-Modules Based on Problem-Based Learning to Enhance Problem-Solving Skills and Student Self-Efficacy

*** Hadira, Murni Sapta Sari, Sulisetijoni**

Biology Education Department, Faculty of Mathematics and Natural Sciences (FMIPA). Jl. Semarang No. 5, Malang 65145, Indonesia

* Corresponding Author e-mail: hadiradira2@gmail.com

Received: December 2023; Revised: January 2024; Published: March 2024

Abstract

This study aimed to develop and assess the validity, feasibility, and effectiveness of a problem-based learning e-module for plant development. The research was conducted at Universitas Negeri Malang and involved 63 third-semester biology students. The research followed the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The validity test and expert assessment were conducted by three faculty members (one content expert, one media expert, and one practitioner expert). The effectiveness was evaluated based on pretests and posttests on problem-solving skills and self-efficacy and analyzed using ANCOVA for each indicator. The results of the media validity test showed a score of 89.33% in the valid category, the content experts obtained a score of 100% in the very valid category, and the practitioner experts obtained a score of 96.19% in the very practical category. The test results for problem-solving skills and self-efficacy showed significant values (0.002) and (0.023), respectively, both below 0.05. This indicates a significant difference in the mean scores between classes that used the problem-based e-module and classes that used problem-based learning without e-modules. Based on these findings, it can be concluded that the developed e-module is highly suitable as a learning resource for students.

Keywords: Learning resources; e-module; Plant development structures; Problem-based learning

How to Cite: Hadira, H., Sari, M. S., & Sulisetijono, S. (2024). Development of E-Modules Based on Problem-Based Learning to Improve Problem-Solving Skills and Student Self-Efficacy. *Jurnal Penelitian Dan Pengkajian Ilmu Pendidikan: E-Saintika*, *8*(1), 86–101. https://doi.org/10.36312/esaintika.v8i1.1622

https://doi.org/10.36312/esaintika.v8i1.1622

INTRODUCTION

Problem-solving skills refer to an individual's ability to explore and generate creative strategies to acquire knowledge in order to find solutions to encountered problems (Csapó & Funke, 2017). Problem-solving is an essential component of the problem-solving process because it enables the easy resolution of arising issues by understanding the problem at hand (Özreçberoğlu & Çağanağa, 2018). These skills are considered indicators of intellectual behavior and high-level thinking abilities that students should master (Akben, 2020; Zajuli et al., 2019).

An analysis was conducted to assess the need for problem-solving skills among biology education students at Universitas Negeri Malang who were enrolled in the Plant Development Structure course. The average values of students' problem-solving skills were as follows: 70.9% for identifying problems, falling into the category of sufficient; 56.9% for applying problem-solving steps, falling into the category of insufficient; 76.5% for identifying solutions, falling into the category of sufficient; 46.8% for evaluating solutions, falling into the category of very insufficient; 56.7% for defending solutions, falling into the category of insufficient; 40.8% for applying real-world applications, falling into the category of very insufficient; 42.3% for inductive reasoning, falling into the category of very insufficient; and 43.4% for deductive reasoning, falling into the category of very insufficient. The analysis clearly indicates the need for improvement in all aspects of problem-solving skills (Malik et al., 2023).

The low problem-solving skills can also be attributed to students' incomplete mastery of problem identification. Another factor contributing to the low problem-solving skills is the difficulty students face in learning abstract concepts (Putranto et al., 2022). Therefore, stricter supervision during task implementation is necessary to support students in developing their problem-solving skills (Y. I. Sari et al., 2021). Additionally, possessing good problem-solving skills alone is not sufficient; belief in self-efficacy also plays a crucial role in the effective utilization of problem-solving skills (Ancel, 2016).

Self-efficacy is a key concept in education that contributes to enhanced learning, success, and student motivation (Van Dinther et al., 2011). Self-efficacy influences one's feelings, thoughts, motivation, and behavior, meaning that internal beliefs impact abilities and personal decision-making (Bandura, 1993). Self-efficacy is a critical aspect of belief, as it determines an individual's ability to persist and have confidence in problem-solving (Kırkıç & Çetinkaya, 2020). Furthermore, self-efficacy is an important variable for predicting behavioral changes in students (Demirören et al., 2016).

Based on the analysis of self-efficacy needs among biology education students at Universitas Negeri Malang, the indicators reveal that the average level of task completion is 54%, which falls into the insufficient category. The indicator for task difficulty is 61.3%, categorized as sufficient. The indicator for optimism in facing tasks is 62.1%, falling into the sufficient category. The indicator for perseverance in learning is 58.9%, categorized as insufficient. The indicator for perseverance in task completion is 62.1%, falling into the sufficient category. The indicator for mastery of assigned tasks is 58.1%, categorized as insufficient. The indicator for mastery of learning materials is 60.5%, categorized as sufficient. The indicator for time management is 61.3%, categorized as sufficient. Based on the analysis conducted, all indicators of self-efficacy are categorized as insufficient, indicating the need for improvement (Malik et al., 2023).

The low self-efficacy is influenced by internal and external factors among students (Mukti & Tentama, 2019). Internal factors include interest, patience, resilience, character, and learning motivation. External factors include attachment style, warmth, goal orientation, enactive mastery experiences, and verbal persuasion (Dewi et al., 2023). Lack of engagement in the learning process also contributes to low self-efficacy among students (Freire et al., 2020). To address these issues, efforts should be made to enhance problem-solving skills and self-efficacy in plant developmental structure learning. The first step is to improve the quality of learning (Fuad et al., 2017). One way to do this is by developing innovative teaching materials and creating learning tools that align with current advancements (Kukulska-Hulme et al., 2022).

An electronic module, or e-module, is a digital version of a printed module that can be accessed on a computer and designed using appropriate software (Syarlisjiswan et al., 2021). E-modules are self-instructional, self-contained, stand-alone, adaptive, and user-friendly (Depdiknas, 2008). E-modules can meet the diverse learning needs and problem-solving skills of students, as they are practical and effective for learning (Neo et al., 2015). Research has shown that e-modules are effective in improving problem-solving skills (Malik et al., 2023).

Furthermore, efforts to enhance self-efficacy also involve innovative approaches, such as utilizing e-modules, although there are limitations. Due to educational policies that limit access to guidance lessons, e-modules can become a promising tool to reinforce students' self-efficacy (Yosef et al., 2023). Several studies have shown that students who successfully use e-learning modules have strong reading comprehension skills (Vallespin, 2021), positive attitudes towards academic performance (Bacomo et al., 2022), and high levels of involvement (Rajabalee & Santally, 2021). The effectiveness of using modules during classroom activities has also been demonstrated in various studies (Saper & Iksan, 2016; Wardani & Daharnis, 2022), showing a moderate level of effectiveness (Ambayon, 2020).

The development of an e-module should employ an approach, method, or model that provides a focused and structured learning process (Uma'iyah et al., 2023). When developing e-module teaching materials to enhance students' problem-solving skills and self-efficacy, the problem-based learning model is more effective. Problem-based learning is a constructivist learning model that emphasizes prior knowledge to help students solve problems (Mulyanto et al., 2018).

Problem-based learning instructional models have been shown to enhance students' problem-solving abilities (Parno et al., 2019). Integrating an e-module with an instructional model is considered to be a supportive approach in facilitating student activities and making learning more effective in achieving the intended learning objectives (Jaenudin et al., 2017). The problem-based learning instructional model challenges students to explore and discover new knowledge, provides opportunities for them to apply their knowledge in real-world scenarios, and allows students to master learning concepts as a means of solving real-world problems (Y. P. Sari et al., 2019). Furthermore, the problem-based learning model has been found to be associated with students' self-efficacy in learning (Demirören et al., 2016).

The Plant Developmental Structure course has the potential to motivate students to enhance their problem-solving skills and self-efficacy. This course greatly assists students in improving their understanding and insight into problem-solving approaches related to plant symptoms. Common learning challenges encountered in the plant developmental structure material include difficulties in identifying structures and comprehending the relationship between the structure and function of plant tissues and organs. Based on a needs analysis conducted with biology education students at Universitas Negeri Malang, 86% of them expressed interest in using instructional materials in the form of e-modules for learning about plant developmental structures. This is because students require easily accessible instructional materials in the form of e-modules that can be flexibly used anytime and anywhere, using the electronic devices they possess.

The needs analysis conducted with Biology Education lecturers at Universitas Negeri Malang has indicated a significant demand for the development of interactive e-modules that integrate problem-solving skills and self-efficacy. This is crucial in providing students with new insights and a deeper understanding of the plant developmental structure material. Additionally, it complements students' existing learning resources and harnesses the positive benefits of smartphone usage. Thus, the aim of this research is to develop a problem-based learning e-module on plant developmental structure to enhance students' problem-solving skills and self-efficacy.

METHOD

Research Design and Procedures

The e-module is developed using the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation) (Branch, 2014). The analysis phase aims to identify learning needs, desired learning objectives, and learning environment conditions, as well as to develop a product development plan. The analysis stage involves distributing a needs analysis questionnaire to students and teachers, creating a schedule and plan for the sequence of activities in the e-module development, and designing a storyboard.

The design phase aims to create a product that addresses the analyzed issues and produces an initial design concept. In this stage, the design activities involve creating a learning activity design, assessing the validity and feasibility of the e-module, and designing field test procedures for use in the implementation phase. The design stage becomes crucial to ensure that the developed e-module meets the desired standards and can provide an optimal learning experience.

The development phase aims to actualize the ideas designed in the design phase. This stage involves creating content, selecting supporting media, developing guides for students and instructors, and conducting formative revisions carried out by instructional experts, subject matter experts, and practitioners to test the theory and feasibility of the e-module for improvement. Formative revision consists of three stages: individual trials, small group trials, and field trials.

The implementation phase aims to apply learning using the developed product, which is the revised and validated e-module from the development phase. The implementation phase's main goal is to successfully integrate the e-module into the learning process, providing a positive impact on students. In this stage, the e-module is implemented in the learning environment according to the predetermined plans and objectives. This involves executing learning activities using the e-module, both by students and educators, and ensuring that all components of the e-module function properly.

The evaluation stage is conducted after the implementation process in the classroom and data has been obtained. The results of this stage can serve as a benchmark for the developed e-module, confirming its validity. Validation of the e-module involves experts in media, content, and field practitioners. The criteria for content experts include biology professors with a minimum Ph.D. level of understanding of the developmental structure of plants. Practitioner experts are Biology professors with a minimum of a Master's level of understanding of the developmental structure of plants. Criteria for media and instructional material experts include expertise in instructional design and a minimum of a Master's level of understanding in Learning Technology.

Data Analysis on Validity and Practicality

The validity and practicality of the module are assessed by employing the following formula. The research and development data analysis technique encompasses quantitative and qualitative descriptive analysis. Quantitative analysis is utilized to examine the validation scores of the e-module, as assessed by content experts, instructional material experts, biology education practitioners, problem-solving skills tests, and self-efficacy questionnaires administered to students. Qualitative descriptive analysis is employed to evaluate comments and suggestions from content experts, instructional material experts, and biology education practitioners. The pretest and posttest results of problem-solving skills and self-efficacy are analyzed using analysis of covariance (ANCOVA). The data analysis outcomes of e-module validation and practicality are presented using a Likert scale, subsequently subjected to descriptive analysis in terms of percentages, and aligned with the validity and practicality criteria outlined by Akbar (2013). The formulas applied is presented in Equation 1 with, v: Percentage of e-module validity; Tse: Total validator assessment score; and TSh: Maximum total assessment score.

$v = \frac{TSe}{TSh} \times 100\%$ .... (Equation 1)

The percentage of e-module validity is adjusted according to the criteria outlined in Table 1 to evaluate the results of the validity analysis data.

Table 1. Validity Criteria for E-module

Value Range (%)	Validity Criteria
81.00-100.00	Very Valid
61.00-80.00	Valid
41.00-60.00	Less valid
21.00-40.00	Invalid
00.00-20.00	Very Invalid

The percentage of practicality in the e-module is adjusted according to the criteria for evaluating the data from the practicality analysis, as specified in Table 2.

Table 2. Practical Criteria for E-module

Value Range (%)	Validity Criteria
81.00-100.00	Very Practical
61.00-80.00	Practical
41.00-80.00	Less Practical
21.00-40.00	Not Practical
00.00-20.00	Very Impractical

e-Module's Effectiveness

The research was conducted utilizing a Quasi-Experimental Design with a Nonrandomized Control Group Pretest-Posttest Design (Fraenkel et al., 2012). The study population consisted of all third-semester students majoring in biology education at Universitas Negeri Malang. The sample for this study included 63 students, who were divided into two classes: an experimental class and a control class. Random sampling was employed as the sampling technique. The quasi-experimental research design involved administering a pretest (measurement before treatment) and posttest (measurement after treatment) to both the experimental class, which implemented an e-module-based problem-based learning, and the control class, which utilized a problem-based learning model without an e-module. The design of this quasi-experimental research can be seen in Table 3 Q1, representing pretest scores of problem-solving skills and self-efficacy; with Q2, representing posttest scores of problem-solving skills and self-efficacy; X1, representing treatment with a problem-based learning-based e-module; and X2, representing treatment with a problem-based learning model.

Table 3. The Effectiveness Test Design

Subjects	Pretest	Treatment	Posttest
Treatment Group	Q1	X1	Q2
Control Group	Q2	X2	Q2

The effectiveness of the e-module was assessed by analyzing the pretest and posttest results of problem-solving skills using ANCOVA for each indicator. The effectiveness test data consisted of quantitative data that was analyzed through a one-way ANCOVA. Prior to conducting ANCOVA, prerequisite tests, such as normality and homogeneity tests, were performed. ANCOVA was selected to analyze the differences in the mean problem-solving skills and self-efficacy of students in the experimental and control groups. The reason for choosing ANCOVA was its accuracy in assessing the impact of the treatment on problem-solving skills and self-efficacy while minimizing potential bias stemming from initial differences between the treatment and control groups. The utilization of ANCOVA provided greater confidence in the observed results, facilitating a stronger interpretation of the treatment's effects on problem-solving skills and self-efficacy. The ANCOVA analysis was conducted using SPSS 23.

Ethical Considerations

The research described in this study adheres to ethical principles in research involving human subjects. Prior to data collection, informed consent was obtained from all participants, including content experts, instructional material experts, biology education practitioners, and third-semester students majoring in biology education at Universitas Negeri Malang. Participants were fully informed about the study's nature, purpose, and their rights as participants. They were assured of confidentiality and anonymity, with all data securely stored and accessible only to authorized personnel. The study protocol was reviewed and approved by the appropriate institutional review board (IRB) or ethics committee of Universitas Negeri Malang, ensuring compliance with ethical guidelines and standards. Throughout the research process, participants' dignity, privacy, and well-being were prioritized, and any potential risks or discomfort associated with participation were minimized. Finally, the research findings will be disseminated transparently and responsibly, contributing to knowledge advancement while upholding the highest ethical standards in research practice.

RESULTS AND DISCUSSION

Results

The development of the e-module on plant developmental structure, utilizing problem-based learning, is based on the ADDIE model. The model consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. During the analysis stage, the focus is on conducting a needs analysis to establish the foundation for e-module development. This involves determining learning objectives and formulating them through a research method based on learning outcomes. The content for the e-module is compiled from various sources such as books and journals.

The e-module is designed using Google Sites and involves the collaboration of experts in media and instructional design, subject matter experts, and lecturers specializing in plant developmental structure.

The design phase is where concrete learning plans start to take shape after gathering the results of the needs analysis. This phase produces an initial design of the e-module on plant developmental structure, aimed at enhancing the problem-solving skills and self-efficacy of biology students. It involves detailed planning of the entire learning process, taking into consideration the students' needs, the technology utilized, and the learning objectives to be achieved.

The third stage is development, where the actual process of e-module development takes place. The outcome of this stage is a validated e-module on the developmental structure of plants, ready to be implemented. Based on research findings, the e-module consists of three main sections: the main part, which includes the cover, introduction, usage instructions, graduate learning outcome standards, and learning outcomes; the core section, which contains content, student learning activities involving problem-based learning, and evaluations; and the closing section, which includes a glossary of important vocabulary used in the e-module and a bibliography. Figures 2 and Figure 3 display some of the key features of the e-module.

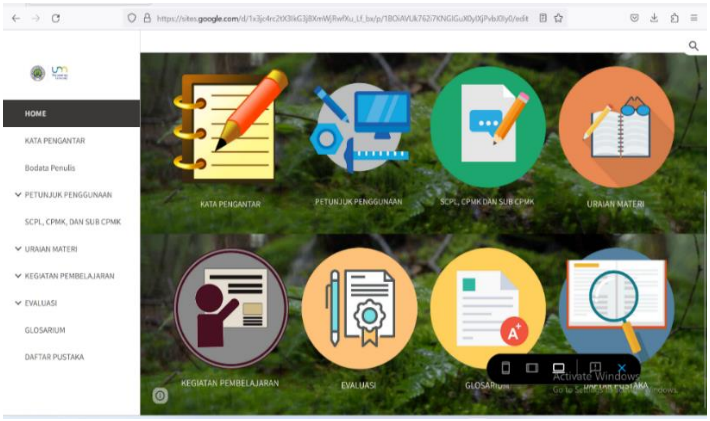
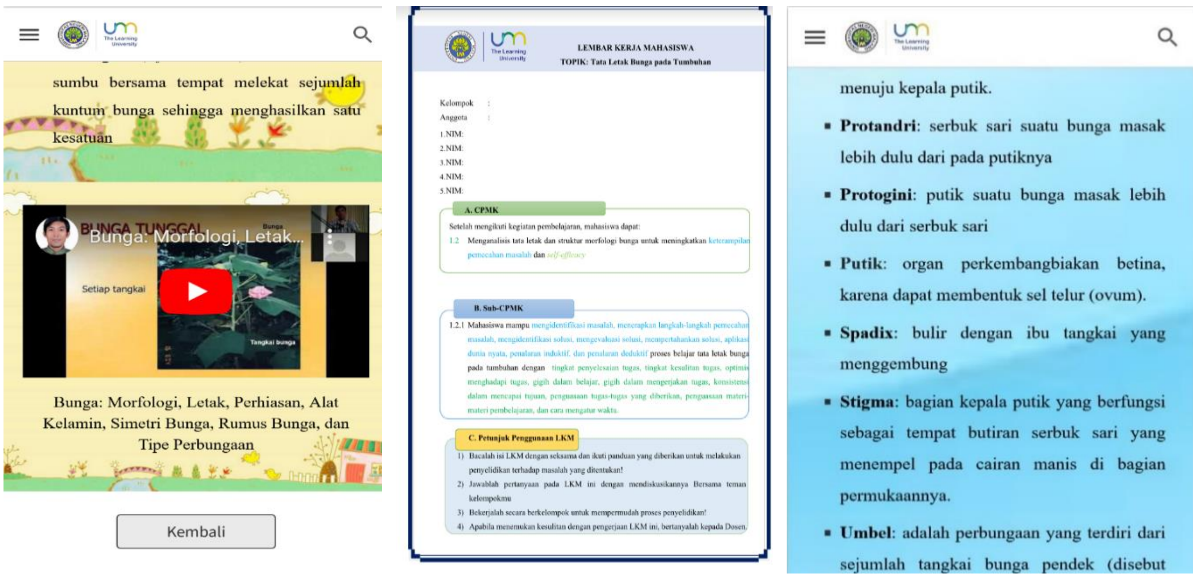


Figure 1. The Main Display Features of the E-module



a b c

Figure 2. (a) Content Features, (b) Student Worksheet Features, (c) Glossary Features

The implementation phase involves the application of the designed product, which is the problem-based learning-based e-module on plant developmental structure that has been revised and validated. The researcher conducts the learning process following the syntax of problem-based learning. Students participating in this study are first provided with an informed consent form. At the beginning of the learning, students are given an initial test (pretest), and at the end of the learning, they are given a final test (posttest) on problem-solving skills and self-efficacy.

The evaluation phase is the final stage in the development of the e-module. The purpose of the evaluation phase is to assess the quality of the problem-based learning-based e-module on plant developmental structure before or after implementation. The intended evaluation is to improve the e-module at each stage, resulting in an e-module suitable for the learning process. According to Branch (2014), there are three levels of evaluation in the ADDIE model: level one perceptions, level two learning, and level three performance.

Expert Content Validation

Validation by content experts consists of eight aspects, comprising a total of 40 questions. These aspects encompass the evaluation of the title, examples or illustrations, images/photos/videos, language, depth or breadth of content, accuracy of material concepts, currency of material, and contextual relevance of material. The findings of the content expert validation analysis are provided in Table 4.

Table 4. Expert Content Validation

Aspects	Maximum Score	Obtained Score	Average Score (%)	Criteria
Title	15	15	100	Very Valid
Examples of Illustrations	15	15	100	Very Valid
Images/Photos/Videos	15	15	100	Very Valid
Language	15	15	100	Very Valid
Depth or Breadth of Content	55	55	100	Very Valid
Accuracy of Material Concepts	55	55	100	Very Valid
Currency of Material	15	15	100	Very Valid
Contextual Relevance of Material	15	15	100	Very Valid
Average Total	200	200	100	Very Valid

Table 4 displays the results that indicate a validation analysis by content experts with a 100% validity rate. This high validity rating confirms that the content of this e-module has been thoroughly reviewed and requires no revisions. The material's completeness and comprehensiveness have been tailored to meet the predetermined competencies. Furthermore, the coherent structure of the e-module will enhance students' understanding of key concepts throughout the learning process. By aligning the content with the expected competencies and proficiency levels in education (Tsai et al., 2017), instructors can effectively oversee the teaching materials within the e-module.

Media Expert Validation

Validation by media experts includes 13 aspects, comprising a total of 45 questions that assess various elements such as e-module design, e-module cover design, self-instruction, self-containedness, stand-alone capability, adaptivity, user-friendliness, consistency, media device compatibility, multimedia utilization, and software applications. The findings of the media expert validation analysis are presented in Table 5.

Table 5. Media Expert Validation

Aspects	Maximum Score	Obtained Score	Average Score	Criteria
Cover design of the e-module	30	28	93.33%	Very Valid
E-module design	70	63	82.85%	Very Valid
Self-instruction	25	24	96%	Very Valid
Self-contained	5	4	80%	Valid
Stand alone	5	5	100%	Very Valid
Adaptive	10	10	100%	Very Valid
User friendly	15	15	100%	Very Valid
Consistency	15	15	100%	Very Valid
Media devices	5	5	100%	Very Valid
Utilization of multimedia	10	9	90%	Very Valid
Software applications	5	4	80%	Valid
Design	10	8	80%	Valid
Layout of the e-module	20	20	100%	Very Valid
Average Total	225	210	89.33%	Very Valid

Table 5 presents the results that indicate a validation analysis percentage of 89.33%. This percentage signifies that the validation analysis conducted by media experts falls within the valid category. The validation test for this E-module has resulted in a decision with minor revisions. The validation results of the e-module ensure that the outlined learning objectives can be objectively measured and aligned with the predetermined indicators (Kurniawan & Syafriani, 2021). These findings are consistent with previous research, suggesting that an e-module is considered valid when it proves to be beneficial for education (Ananda & Usmeldi, 2023). Furthermore, these results align with the research findings, demonstrating that the objectives and purpose of the e-module are designed for universal usability and effectiveness throughout various settings and times (Putri & Junaedi, 2022).

Practitioner Expert Validation

Validation by expert practitioners comprises seven aspects, encompassing a total of 21 statements that assess the completeness of components, characteristics of the e-module, presentation, language, material, access and usage, as well as learning objectives. The outcomes of the analysis conducted during the validation process by expert practitioners are presented in Table 6.

Table 6. Practitioner Expert Validation

Aspects	Maximum Score	Obtained Score	Average Score	Criteria
Completeness of components	5	5	100%	Very practical
Characteristics of the e-module	15	13	86.67%	Practical
Presentation	15	15	100%	Very practical
Language	15	14	93.33%	Very practical
Material	20	19	95%	Very practical
Access and usage	20	20	100%	Very practical
Learning objectives	15	15	100%	Very practical
Average total	105	101	96.19%	Very practical

Table 6 displays the results that indicate a percentage of 96.19%. This percentage signifies that the validation analysis conducted by expert practitioners falls within the highly practical category. The test conducted by the validator for this e-module resulted in minor revisions. A practical and user-friendly e-module facilitates the learning process, improves efficiency, utilizes easily comprehensible language, and can be adapted by students according to their own pace of learning (Yerimadesi et al., 2023). The practicality validation of the e-module's validity is evaluated based on its alignment with its components and its compliance with the steps of the learning model (Yulkifli et al., 2023).

Effectiveness Test Results

The effectiveness test results of the e-module were obtained by analyzing the pretest and posttest scores of problem-solving skills. The problem-solving skills consisted of eight items, each containing a different indicator. Additionally, self-efficacy was measured using forty-three statements. The data from the pretest and posttest were analyzed using ANCOVA data analysis.

Table 7. The Results ANCOVA of Problem-Solving Skills

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	928.686[a]	2	464.343	10.400	.000
Intercept	4697.082	1	4697.082	105.199	.000
X	211.472	1	211.472	4.736	.033
Treatment	445.740	1	445.740	9.983	.002
Error	2678.965	60	44.649		
Total	371917.000	63			
Corrected Total	3607.651	62			

According to Table 7, the p-value (0.002) is less than 0.05. This suggests a statistically significant difference in the average self-efficacy between the group using the problem-based learning-based e-module and the group using the problem-based learning model without the e-module.

Table 8. The Results of ANCOVA for Self-Efficacy

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	606.316[a]	2	303.158	9.791	.000
Intercept	1765.186	1	1765.186	57.012	.000
X	292.156	1	292.156	9.436	.003
Treatment	167.646	1	167.646	5.415	.023
Error	1857.684	60	30.961		
Total	341264.000	63			
Corrected Total	2464.000	62			

Based on Table 8, the significance value (0.023) is less than 0.05, indicating a statistically significant difference in mean self-efficacy between the class using the problem-based learning-based e-module and the class using the problem-based learning model without the e-module. The e-module developed in this study is based on problem-based learning and includes comprehensive components that facilitate independent and conventional learning for students. Furthermore, it enhances content mastery for both professors and students. The integration of technology in the e-module makes the presentation and delivery of information visually accessible, which is crucial in the learning process. E-modules have been shown to be highly effective in facilitating student learning and improving their understanding of the material (Sadimin et al., 2017). The development of the e-module aims to enhance students' problem-solving skills through the problem-based learning model, and it has the potential to improve their problem-solving abilities (Fernandu et al., 2022). Previous research has also indicated that the development of e-modules can enhance students' problem-solving skills (Malik et al., 2023) and increase their self-efficacy (Jeske et al., 2014).

Based on the results of the effectiveness test, there is a significant difference in the mean scores of self-efficacy and problem-solving skills between the class using problem-based learning e-modules and the class using the problem-based learning model without e-modules. The e-module adapts the characteristics, format, and sections of printed modules in general (Effendi et al., 2018). The development of e-modules can enhance problem-solving skills and self-efficacy in students, as it offers several advantages. Students tend to be more diligent in completing learning materials through the e-module. Additionally, the developed e-module can train students to enhance their thinking skills in the problem-solving process (Novita et al., 2022). In this study, the e-module focuses on the developmental structure of plants. The problems addressed in the learning process are derived from real-life issues faced by students, enabling them to more easily conduct investigations to solve problems (Rahayu & Kuswanto, 2021).

The learning activities outlined in the e-module prioritize group discussions, where students engage with their peers to analyze problems presented in the articles provided within the e-module. Through these discussions, students have the opportunity to express their opinions and interact with group members to find appropriate solutions to the issues at hand. This process can positively contribute to the development of students' self-efficacy, which refers to an individual's belief in their ability to succeed in a specific task or activity. The selection of appropriate learning resources can also facilitate students' understanding of the taught material (Daryono & Rochmadi, 2020; Rahmatunisa et al., 2022). Additionally, educators should provide varied learning experiences to prevent students from becoming bored during the classroom learning process (Amhag et al., 2019). The e-module itself is interactive, facilitates navigation, displays images, text, and videos, and is equipped with tests that provide automatic feedback (Rehman & Fatima, 2020).

In the development research, the learning model used is problem-based learning. Problem-Based Learning is an innovative instructional model characterized by the use of real-world problems to help students apply their existing knowledge to solve a problem. It can enhance problem-solving skills and self-efficacy (Setiawati & Agoestanto, 2023). The use of problem-based learning-based e-modules can significantly enhance students' self-efficacy and problem-solving skills. By presenting learning content interactively and allowing students to engage in project-based problem-solving actively, e-modules provide opportunities for students to develop self-efficacy in tackling tasks and challenges. Problem-based learning begins with the presentation of an open, unstructured, and contextual real-world problem, which triggers and motivates students to identify and learn the concepts necessary to solve the problem (Rubini et al., 2019). Students participate in group discussions to solve the presented problem. After completing the group discussion, students communicate the outcomes of their group discussions through presentations (Balan et al., 2019).

CONCLUSION

The research on the development of an e-module for plant development structure, which incorporates the problem-based learning model, to enhance problem-solving skills and self-efficacy in biology students, in accordance with the taught material, has been found to be valid. According to the results of the validation test, the e-module received a rating of 89.33% from media and instructional experts, categorizing it as valid; a rating of 100% from material experts, categorizing it as highly valid; and a rating of 96.19% from practitioner validation, categorizing it as highly practical. The effectiveness test results for problem-solving skills showed a significant value of 0.002 (less than 0.05). Similarly, the effectiveness test for self-efficacy yielded a significant value of 0.023 (less than 0.05). This indicates a significant difference in mean self-efficacy and problem-solving skills between the class using the problem-based learning e-module and the class using the problem-based learning model without the e-module.

RECOMMENDATION

The development of e-modules should be conducted with careful consideration for network connectivity support in order to enhance the seamless utilization of media. Furthermore, the integration of e-module development with diverse learning models beyond problem-based learning should be explored while taking into account the specific characteristics of the course and lecture material. In tandem with the rapid advancements in digital technology, e-modules ought to incorporate more sophisticated interactive elements, such as simulations, interactive animations, and other multimedia components that can augment engagement. This will contribute to the creation of a compelling and impactful learning experience, aligning with the ongoing evolution of digital technology.

Author Contributions

All authors have sufficiently contributed to the study and agreed with the results and conclusions. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Conflict of Interests

The authors declare no conflict of interest.

REFERENCES

Akbar, S. (2013). *Instrumen Perangkat Pembelajaran* (Bandung). PT. Remaja Rosda Karya. //perpustakaan.iahntp.ac.id/index.php?p=show_detail&id=3204

Akben, N. (2020). Effects of the Problem-Posing Approach on Students' Problem Solving Skills and Metacognitive Awareness in Science Education. *Research in Science Education*, *50*(3), 1143–1165. https://doi.org/10.1007/s11165-018-9726-7

Ambayon, C. M. (2020). Modular-Based Approach and Students' Achievement in Literature. *International Journal of Education and Literacy Studies*, *8*(3), 32. https://doi.org/10.7575/aiac.ijels.v.8n.3p.32

Amhag, L., Hellström, L., & Stigmar, M. (2019). Teacher Educators' Use of Digital Tools and Needs for Digital Competence in Higher Education. *Journal of Digital Learning in Teacher Education*, *35*(4), 203–220. https://doi.org/10.1080/21532974.2019.1646169

Ananda, P. N., & Usmeldi, U. (2023). Validity and Practicality of E-Module Model Inquiry Based Online Learning to Improve Student Competence. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 2010–2017. https://doi.org/10.29303/jppipa.v9i4.3563

Ancel, G. (2016). Problem-Solving Training: Effects on the Problem-Solving Skills and Self-Efficacy of Nursing Students. *Eurasian Journal of Educational Research*, *16*(64), 231–246. https://doi.org/10.14689/ejer.2016.64.13

Bacomo, A. C. C., Daculap, L. P., Ocampo, M. G. O., Paguia, C. D., Pentang, J. T., & Bautista, R. M. (2022). Modular Learning Efficiency: Learner's Attitude and Performance Towards Self-Learning Modules. *International Multidisciplinary Research Journal*, *4*(2), 60–72. https://doi.org/10.54476/s149512

Balan, L., Yuen, T., & Mehrtash, M. (2019). Problem-Based Learning Strategy for CAD Software Using Free-Choice and Open-Ended Group Projects. *Procedia Manufacturing*, *32*, 339–347. https://doi.org/10.1016/j.promfg.2019.02.223

Bandura, A. (1993). Perceived Self-Efficacy in Cognitive Development and Functioning. *Educational Psychologist*, *28*(2), 117–148. https://doi.org/10.1207/s15326985ep2802_3

Branch, R. M. (2014). *Instructional design: The addie approach*. Springer.

Csapó, B., & Funke, J. (Eds.). (2017). *The Nature of Problem Solving: Using Research to Inspire 21st Century Learning*. OECD. https://doi.org/10.1787/9789264273955-en

Daryono, R. W., & Rochmadi, S. (2020). Development of learning module to improve competency achievement in the department of civil engineering education in Indonesia. *Psychology, Evaluation, and Technology in Educational Research*, *3*(1), 34–43. https://doi.org/10.33292/petier.v3i1.54

Demirören, M., Turan, S., & Öztuna, D. (2016). Medical students' self-efficacy in problem-based learning and its relationship with self-regulated learning. *Medical Education Online*, *21*(1), 30049. https://doi.org/10.3402/meo.v21.30049

Depdiknas. (2008). *Penulisan Modul*. Kemendikbud.

Dewi, A. K., Lestari, S. M. P., & Sandayanti, V. (2023). Can self-efficacy have a role in learning interest. *Psikostudia : Jurnal Psikologi*, *12*(2), 302. https://doi.org/10.30872/psikostudia.v12i2.10829

Effendi, K. N. S., Zulkardi, Putri, R. I. I., & Yaniawati, P. (2018). The development of mathematics student worksheet for school literacy movement. *Journal of Physics: Conference Series*, *1088*, 012033. https://doi.org/10.1088/1742-6596/1088/1/012033

Fernandu, D. E., Abdurrahman, A., & Lengkana, D. (2022). Design and Validation of STEM Integrated e-Modules on Environmental Pollution to Improve Problem-Solving Skills. *Jurnal Pendidikan MIPA*, *23*(2), 754–765. https://doi.org/10.23960/jpmipa/v23i2.pp754-765

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education* (8th ed). McGraw-Hill Humanities/Social Sciences/Languages.

Freire, C., Ferradás, M. D. M., Regueiro, B., Rodríguez, S., Valle, A., & Núñez, J. C. (2020). Coping Strategies and Self-Efficacy in University Students: A Person-Centered Approach. *Frontiers in Psychology*, *11*, 841. https://doi.org/10.3389/fpsyg.2020.00841

Fuad, N. M., Zubaidah, S., Mahanal, S., & Suarsini, E. (2017). Improving Junior High Schools' Critical Thinking Skills Based on Test Three Different Models of Learning. *International Journal of Instruction*, *10*(01), Article 01. https://doi.org/10.12973/iji.2017.1017a

Jaenudin, A., Baedhowi, B., & Murwaningsih, T. (2017). The Effectiveness of the E-Module of Economics Learning on Problem-Based Learning used to Improve Students' Learning Outcomes. *Proceedings of the International Conference on Teacher Training and Education 2017 (ICTTE 2017)*. International Conference on Teacher Training and Education 2017 (ICTTE 2017), Surakarta, Indonesia. https://doi.org/10.2991/ictte-17.2017.32

Jeske, D., Backhaus, J., & Stamov Roßnagel, C. (2014). Self-regulation during e-learning: Using behavioural evidence from navigation log files. *Journal of Computer Assisted Learning*, *30*(3), 272–284. https://doi.org/10.1111/jcal.12045

Kırkıç, K. A., & Çetinkaya, F. (2020). The relationship between preschool teachers' self-efficacy beliefs and their teaching attitudes. *International Journal of Evaluation and Research in Education (IJERE)*, *9*(4), 807. https://doi.org/10.11591/ijere.v9i4.20670

Kukulska-Hulme, A., Bossu, C., Charitonos, K., Coughlan, T., Ferguson, R., FitzGerald, E., Gaved, M., Guitert, M., Herodotou, C., Maina, M., Prieto-Blazquez, J., Rienties, B., Sangrà, A., Sargent, J., Scanlon, E., & Whitelock, D. (2022). *INNOVATING PEDAGOGY 2022 Exploring new forms of teaching, learning and assessment, to guide educators and policy makers*. The Open University.

Kurniawan, R. & Syafriani. (2021). The validity of e-module based on guided inquiry integrated ethnoscience in high school physics learning to improve students' critical thinking. *Journal of Physics: Conference Series*, *1876*(1), 012067. https://doi.org/10.1088/1742-6596/1876/1/012067

Malik, A., Al-Hanafi, M. A., Chusni, M. M., & Nugraha, A. R. (2023). Development of CORE-based Electronic-modules to Improve Students' Problem-Solving Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6415–6424. https://doi.org/10.29303/jppipa.v9i8.3172

Mukti, B., & Tentama, F. (2019). Faktor-faktor yang mempengaruhi efikasi diri akademik. *Prosiding Seminar Nasional Magister Psikologi Universitas Ahmad Dahlan*, *0*, Article 0.

Mulyanto, H., Gunarhadi, G., & Indriayu, M. (2018). The Effect of Problem Based Learning Model on Student Mathematics Learning Outcomes Viewed from Critical Thinking Skills. *International Journal of Educational Research Review*, *3*(2), 37–45. https://doi.org/10.24331/ijere.408454

Neo, M., Park, H., Lee, M.-J., Soh, J., & Oh, J.-Y. (2015). Technology acceptance of healthcare e-learning modules: A study of Korean and malaysian students' perceptions. *Turkish Online Journal of Educational Technology*, *14*(2), 181–194.

Novita, R. D., Aminatun, T., & Daryono, R. W. (2022). E-Modules Through Flipped Classroom and PBL Models on Environmental Pollution Material to Increase

Problem-Solving Ability. *Journal of Education Technology*, *6*(4), 744–754. https://doi.org/10.23887/jet.v6i4.51656

Özreçberoğlu, N., & Çağanağa, Ç. K. (2018). Making It Count: Strategies for Improving Problem-Solving Skills in Mathematics for Students and Teachers' Classroom Management. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(4). https://doi.org/10.29333/ejmste/82536

Parno, Yuliati, L., & Ni'mah, B. Q. A. (2019). The influence of PBL-STEM on students' problem-solving skills in the topic of optical instruments. *Journal of Physics: Conference Series*, *1171*, 012013. https://doi.org/10.1088/1742-6596/1171/1/012013

Putranto, S., Marsigit, M., & Ratnasari, G. I. (2022). Peer Tutoring with Realistic Mathematics Education in Inclusive Class to Improve Problem-Solving Skills. *Journal of Education Research and Evaluation*, *6*(2), 307–315. https://doi.org/10.23887/jere.v6i2.43651

Putri, M., & Junaedi, I. (2022). Development of Ethnomathematics-Based E-Module Using the Inquiry Learning Model to Improve Mathematical Problem Solving Ability. *Unnes Journal of Mathematics Education*, *11*(2), Article 2. https://doi.org/10.15294/ujme.v11i2.59938

Rahayu, M. S. I., & Kuswanto, H. (2021). The effectiveness of the use of the Android-based Carom games comic integrated to discovery learning in improving critical thinking and mathematical representation abilities. *Journal of Technology and Science Education*, *11*(2), 270. https://doi.org/10.3926/jotse.1151

Rahmatunisa, N., Sofyan, H., Daryono, R. W., & Nurtanto, M. (2022). Feasibility of Clinical Dietetics E-Module to Improve Learning Achievement of Vocational Students. *Journal of Education Technology*, *6*(1), 45–55. https://doi.org/10.23887/jet.v6i1.41542

Rajabalee, Y. B., & Santally, M. I. (2021). Learner satisfaction, engagement and performances in an online module: Implications for institutional e-learning policy. *Education and Information Technologies*, *26*(3), 2623–2656. https://doi.org/10.1007/s10639-020-10375-1

Rehman, R., & Fatima, S. S. (2020). An innovation in Flipped Class Room: A teaching model to facilitate synchronous and asynchronous learning during a pandemic. *Pakistan Journal of Medical Sciences*, *37*(1). https://doi.org/10.12669/pjms.37.1.3096

Rubini, B., Septian, B., & Permana, I. (2019). Enhancing critical thinking through the science learning on using interactive problem based module. *Journal of Physics: Conference Series*, *1157*, 022001. https://doi.org/10.1088/1742-6596/1157/2/022001

Sadimin, S., Hardyanto, W., & Slamet, A. (2017). Developing an E-Module-Based Classroom Action Research Training Model. *The Journal of Educational Development*, *5*(3), Article 3. https://doi.org/10.15294/jed.v5i3.18123

Saper, N., & Iksan, Z. (2016). The Effects of Guidance Module in Islamic Perspective on the Religiosity Among Students with Misbehaviour Issues. *Tinta Artikulasi Membina Ummah*, *2*(1), 2289–2960.

Sari, Y. I., Sumarmi, S., Utomo, D. H., & Astina, I. K. (2021). The Effect of Problem Based Learning on Problem Solving and Scientific Writing Skills. *International Journal of Instruction*, *14*(2), 11–26. https://doi.org/10.29333/iji.2021.1422a

Sari, Y. P., Sunaryo, Serevina, V., & Astra, I. M. (2019). Developing E-Module for fluids based on problem-based learning (PBL) for senior high school students. *Journal of Physics: Conference Series*, *1185*, 012052. https://doi.org/10.1088/1742-6596/1185/1/012052

Setiawati, E. P., & Agoestanto, A. (2023). Development of Problem-Based Learning Mathematical Module with STEM Approach to Improve Problem-Solving Ability and Self Efficacy. *Unnes Journal of Mathematics Education*, *12*(1), 60–71. https://doi.org/10.15294/ujme.v12i1.68716

Syarlisjiswan, M. R., Sukarmin, & Wahyuningsih, D. (2021). The development of e-modules using Kodular software with problem-based learning models in momentum and impulse material. *Journal of Physics: Conference Series*, *1796*(1), 012078. https://doi.org/10.1088/1742-6596/1796/1/012078

Tsai, T. P., Lin, J., & Lin, L. C. (2017). A Flip Blended Learning Approach for ePUB3 eBook-based Course Design and Implementation. *EURASIA Journal of Mathematics, Science and Technology Education*, *14*(1). https://doi.org/10.12973/ejmste/79629

Uma'iyah, N., Wahyuni, S., & Nuha, U. (2023). Development of E-Modules Based On Mobile Learning Applications to Improve Students' Critical Thinking Skills in Science Subject. *JPPS (Jurnal Penelitian Pendidikan Sains)*, *12*(2), 122–137. https://doi.org/10.26740/jpps.v12n2.p122-137

Vallespin, M. R. (2021). Implementation of the 7e Lesson Model to Improve Learner's Conceptual Understanding on Gas Laws. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.3907017

Van Dinther, M., Dochy, F., & Segers, M. (2011). Factors affecting students' self-efficacy in higher education. *Educational Research Review*, *6*(2), 95–108. https://doi.org/10.1016/j.edurev.2010.10.003

Wardani, S. R., & Daharnis, D. (2022). Development of guidance and counseling modules to improve students' skills in responding. *International Journal of Applied Counseling and Social Sciences*, *3*(2), 8–13. https://doi.org/10.24036/005498ijaccs

Yerimadesi, Y., Warlinda, Y. A., Rosanna, D. L., Sakinah, M., Putri, E. J., Guspatni, G., & Andromeda, A. (2023). Guided Discovery Learning-Based Chemistry E-Module and Its Effect on Students' Higher-Order Thinking Skills. *Jurnal Pendidikan IPA Indonesia*, *12*(1), Article 1. https://doi.org/10.15294/jpii.v12i1.42130

Yosef, Y., Rozzaqyah, F., Rahmi, R., Marwah, A. S., & Vilala, V. (2023). Using E-Module in Guidance Lessons to Enhance Multicultural Self-Efficacy of Islamic and Public High School Students. *Islamic Guidance and Counseling Journal*, *6*(2). https://doi.org/10.25217/0020236374100

Yulkifli, Y., Risma, M., Festiyed, F., & Azis, H. (2023). Validity of e-module integrated scientific literacy using the smartphone-assisted IBL model to improve student competence. *Journal of Physics: Conference Series*, *2582*(1), 012051. https://doi.org/10.1088/1742-6596/2582/1/012051

Zajuli, I., Vivanti, D., Miarsyah, M., Ali, A., Pramita, W., & Ageng, T. (2019). HOTS-AEP: Higher Order Thinking Skills from Elementary to Master Students in Environmental Learning. *European Journal of Educational Research*, *8*(4), 935–942. https://doi.org/10.12973/eu-jer.8.4.935