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The Feasibility of an E-Module Integrating SDGs 2.4 Based on Problem-Based Learning (PBL) for Ownership of Learning Skills

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Abstract
This study aims to develop and test the feasibility of an e-module integrating SDGs 2.4 based on the Problem-Based Learning (PBL) model to enhance students' ownership of learning skills. This research is a Research and Development (R&D) study. The development model used in this research is the Lee & Owens development model. The e-module is designed using digital platforms such as Google Sites and Canva, and integrates various learning resources such as multimedia, educational videos, scientific articles, and quizzes. Data collection was carried out through a validation questionnaire involving subject matter experts, media experts, and biology education practitioners to assess the feasibility of the e-module. The questionnaire instrument uses a Likert scale with five evaluation categories. The collected data was analyzed using descriptive quantitative analysis to provide an overall evaluation of the results. The feasibility test results show that the e-module meets high feasibility standards, with a material feasibility score of 100% and a media feasibility score of 99.71%. The results of the learning tools experts' validation showed an average score of 99%, and the feasibility test by biology education practitioners achieved a score of 97.5%. The e-module is deemed highly feasible for use. These findings indicate that digital learning tools such as e-modules can significantly enhance student engagement and motivation, making learning more effective and relevant to real-world challenges.
Keywords: E-module; Feasibility test; Ownership of learning; Problem-Based Learning; SDGs 2.4.

INTRODUCTION

The rapid development of information and communication technology (ICT) has had a significant impact on various sectors of life, including higher education. Initially, ICT served as an administrative tool and a medium for delivering content, but it has now become a primary driving force in the learning process (Alenezi et al., 2023). Technology enables instant access to information without geographical limitations and supports the realization of more flexible, inclusive, and personalized education. Learning, which was previously centered in the classroom, can now be conducted online, allowing students to learn anytime and anywhere with a wider and more diverse range of resources (Bagde et al., 2021, Alenezi et al., 2023). The use of ICT in higher education opens up various opportunities for students and lecturers to interact in more dynamic and innovative ways. The use of online learning platforms, educational apps, and other technology-based learning tools allows for flexible learning, unrestricted by time and space. This enables students to access a broader range of learning resources, including multimedia content, e-books, educational videos, and scientific journals that support understanding. Furthermore, technology allows for direct interaction with lecturers and fellow students through discussion forums and real-time Q&A sessions, which increases student engagement in the learning process. Technology supports more independent learning, giving students the freedom to explore content in-depth and develop the ability to learn autonomously. This approach makes the learning experience more personal and relevant, as it can be tailored to individual student preferences, backgrounds, and conditions to achieve a deeper and more comprehensive understanding of the material being studied. Educational technology also allows for the use of various tools to monitor students' learning progress, provide instant feedback, and enable more accurate self-assessment (Aruleba & Jere, 2022, Chinonso et al., 2023).

Technology has had a significant impact on improving the quality and accessibility of education, enabling students to access various learning resources in a flexible and independent manner (Reddy et al., 2020). One of the innovations resulting from the use of technology in education is the development of e-modules (Berlianti *et al*., 2024). An e-module is a digital learning module designed to provide an interactive learning experience that can be accessed anytime and anywhere (Kurniati *et al*., 2021). This module not only provides structured learning content but also enables students to manage their learning process more independently, according to their individual learning pace and style (Linda Dwi Astuti, 2024) . However, to ensure that technology is used optimally, the main challenge is how it can support the achievement of deeper and more meaningful learning outcomes. Active student engagement in the learning process is a key element in achieving deeper learning objectives (Barbera et al., 2020; Corritore & Love, 2020; Khatter et al., 2024). Technology should not only be used to deliver information but also to encourage students to actively engage in managing and evaluating their learning.

Technology-based learning must be able to build students' sense of responsibility for their own learning, referred to as ownership of learning (Corritore & Love, 2020; Walkington & Bernacki, 2020). Active involvement allows students not only to be passive recipients of information but also to play an important role in determining how they learn, explore the material, and solve problems relevant to real-life situations (Manzano, 2023). However, in practice, this has not yet fully reflected in classroom learning activities. A study conducted by Putri & Alwi (2023) found that about 40.9% of students at the Faculty of Psychology, Universitas Negeri Makassar, showed low engagement during lectures. Many students felt insecure about asking questions, lacked focus, and procrastinated in completing academic tasks. Additionally, 36.4% of students expressed that they were passive in giving opinions or suggestions, while 58% were often involved in classroom activities with thoughts unrelated to the material being studied. These findings indicate a gap between the concept of learning that emphasizes active student participation and the reality in the field. This highlights the need for more effective teaching strategies to encourage active student involvement, so that students can truly become learning agents who contribute significantly to the real educational process (Suhirman *et al*., 2021). One learning model that can be implemented to achieve this goal is Problem-Based Learning (PBL), which gives students the freedom to take full control of their learning process (Hidajat, 2023; Khoiriyah & Roberts, 2025; Wong & Kan, 2022).

The Problem-Based Learning (PBL) model helps students not only receive information they need to learn but also takes responsibility for identifying problems, gathering relevant information, and formulating solutions independently or in groups (Gusman, 2023). This process directly supports the development of ownership of learning, which is the understanding that students must actively engage in managing, planning, and evaluating their learning (Coutts, 2019; Rankin & Casey, 2022). Ownership of learning encourages students to become independent learners and take responsibility for their academic success (Lysne *et al*., 2023). The PBL model provides students with the opportunity to plan learning steps according to their needs, monitor the progress they achieve, and make decisions required to reach learning goals. Thus, students do not only passively receive content but actively organize the learning process, which strengthens their sense of responsibility for academic achievement. Furthermore, PBL also plays a role in developing students' metacognitive skills, which is the ability to reflect on and evaluate the learning strategies used. Students involved in PBL are more likely to recognize their strengths and weaknesses in the learning process and are able to adjust their approach to achieve optimal results (Dita *et al*., 2021).

The integration of Sustainable Development Goals (SDGs) Target 2.4, focusing on enhancing agricultural productivity through sustainable technology, provides strong relevance in the context of Problem-Based Learning (PBL). SDGs 2.4 encourages students to develop awareness of global issues, particularly those related to food security and innovative technology in agriculture. Integrating SDGs 2.4 into learning allows students not only to learn about relevant

theories and concepts but also to engage in the application of real-world solutions that can contribute to global sustainability. This integration can be implemented through technological innovations, one of which is the use of e-modules. E-modules enable students to access learning materials digitally, which not only present theory related to SDGs 2.4 but also introduce challenges and problems requiring practical solutions. E-modules that integrate Sustainable Development Goals (SDGs) Target 2.4, focusing on enhancing agricultural productivity through sustainable technology, play an important role in bridging theoretical knowledge with practical application relevant to global challenges. The use of e-modules based on Problem-Based Learning (PBL) provides students with the opportunity to directly engage in solving real-world problems related to urgent issues such as food security and the application of sustainable technology in the agricultural sector (Birnida Nurissamawati, Yuniawatika, 2024; Firdaus & Pahlevi, 2022; Hadira et al., 2024).

The use of e-modules that integrate SDGs 2.4 and are based on Problem-Based Learning (PBL) not only allows students to gain conceptual knowledge about SDGs 2.4 but also encourages them to develop a sense of responsibility for societal problems, providing a positive impact on the social environment and sustainable development. The goal of this study focuses on the development and feasibility testing of an SDGs 2.4-based e-module, using Problem-Based Learning (PBL) to enhance students' ownership of learning skills.

METHODS

This research applies the Research and Development (R&D) method, focusing on the development and validation of products. The development model used in this study is the Lee & Owens model, which consists of several stages: analysis, design, development, implementation, and evaluation, aimed at producing technology-based products (Febrianti et al., 2022; Kurniawan et al., 2020). The goal of this study is to develop and test the feasibility of an E-Module containing SDGs 2.4, implemented through the Problem-Based Learning (PBL) model for students' ownership of learning skills. This research focuses on the first three stages: analysis, design, and development, which include product validation, evaluation, and necessary revisions to ensure the feasibility of the E-Module for developing students' ownership of learning skills.

The analysis phase aims to obtain valid and relevant data as the foundation for e-module development. This analysis is crucial for identifying the gap between the ideal conditions expected and the reality in the field. The analysis process is divided into two main parts: Needs Assessment and Front-End Analysis, each serving specific purposes that support each other in designing the appropriate solutions for the development of technology-based learning products.

1. Needs Assessment is conducted through surveys with students who have completed the Plant Physiology course and interviews with the course instructors at Universitas Negeri Malang. The data from these surveys and interviews provide insights into aspects that need improvement in the learning process, such as content, teaching methods, and the student-teacher interaction. These findings serve as the basis for designing the development of an e-module that better meets the learning needs.
2. Front-End Analysis aims to gather information related to the product to be developed and formulate solution steps for the problems identified in the needs analysis. This phase includes several analyses, namely: 1) Student Analysis; 2) Technology Analysis; 3) Task Analysis; 4) Critical Incident Analysis; 5) Situation Analysis; 6) Goal Analysis; 7) Problem Analysis; 8) Media Analysis; 9) Existing Data Analysis; and 10) Cost Analysis.

The design phase includes various elements necessary for the development of the e-module, including the collection of teaching materials, creation of storyboards, preparation of schedules, determination of the development team, specification of the product, and identification of learning content. The design steps are as follows:

1. Creating a Schedule: The development plan for the e-module based on SDGs Target 2.4 and Problem-Based Learning (PBL) is carried out systematically, covering the process, resources, schedule, and work mechanisms required to produce the e-module.

Table 1. Schedule of E-module Development Implementation

No	Lee & Owens Stage	May	Jun	Jul	aug	Sep	Oct	Nov	Dec
		The year 2025							
1	*Analyze*								
2	D*esign*								
3	D*evelop*								

2. Determination of Project Team: The project team consists of researchers and supervising lecturers responsible for monitoring the progress of the e-module development.
3. Media Specification: The analysis of the e-module content specification aims to design teaching materials that support Plant Physiology learning through a Problem-Based Learning (PBL) approach, by integrating SDGs Target 2.4 related to food security and sustainable agriculture.

Table 2. E-module Specification Components

No.	Components	Description
1	Font Type and Size	The e-module uses two types of fonts, Lora and Times New Roman, to ensure good readability and visual alignment. Font size 54 is used for titles to highlight the main topic, size 20 for subtitles to separate important sections of the text, and size 12 for the main text body, providing reading comfort and consistency in presenting information.
2	Home	Provides a general explanation about the purpose of the e-module, the importance of understanding SDGs Target 2.4 (Food Security), and the relevance of plant physiology topics in achieving these goals. The module also includes an explanation about the stages of Problem-Based Learning (PBL), introducing ownership of learning and collaboration skills.
3	Table of Contents	Includes sections such as learning identity, learning activities, discussion column, evaluation, descriptive and reflective essays, and assessment rubrics that organize the material, tasks, and assessments to support a structured and measurable learning process.
4	Learning Identity	Presents the learning outcomes (CPMK) and sub-learning outcomes (Sub-CPMK), as well as the learning objectives that students aim to achieve, such as enhancing ownership of learning and collaboration skills in the context of SDGs 2.4.
5	PBL Syntax	The PBL syntax includes 5 phases: 1) Orient students to the problem, 2) Organize students for study, 3) Assist independent and group investigation, 4) Develop and present artifacts and exhibits, and 5) Analyze and evaluate the problem-solving process.

No.	Components	Description
6	Learning Material	Provides material on: 1) Basic concepts of Plant Physiology related to water and nutrients, 2) Water balance in plants, 3) Nutrients and nutrient transportation in plants.
7	Case Studies and Contextual Problems	Located in student worksheets, containing case studies relevant to SDGs 2.4, such as water resource management in agriculture and its impact on agricultural productivity.
8	Collaborative Tasks	A group task where students search for and analyze plant physiology-related problems that could affect agricultural productivity, such as the impact of water or nutrient balance on plant growth, and then provide relevant solutions while connecting their findings to sustainable agricultural practices.
9	Learning Resources	Provides links to scientific articles, educational videos, e-books, and other references that deepen topics related to SDGs 2.4 and plant physiology.
10	Discussion Forum	Contains discussion activities designed to help students understand important concepts in the material being studied. Students can share opinions and discuss topics related to the learning, while practicing collaboration skills such as working together, listening, and solving problems as a group.
11	Evaluation	Assessment of understanding the material is done through tests or quizzes, with questions related to agricultural productivity and the application of plant physiology concepts in sustainable agriculture. Additionally, there is a questionnaire used to measure students' ownership of learning and collaboration skills in group work to ensure effective achievement of learning goals.
12	Post-Reflection and Descriptive	Students are asked to write a post-reflection and descriptive essay that explores their understanding of the material learned and reflect on their involvement in the learning process. This essay aims to enhance ownership of learning by encouraging students to reflect on their learning experience and the application of relevant material.

The development stage of the e-module teaching materials follows the design that was previously conceptualized. Validation is conducted to assess the validity of the e-module. The development stages carried out in this study include the following activities:

1) Pre-Production (Preparation): The results of the pre-production stage include the creation of the initial framework for the e-module, including the layout design and product structure. This begins with the creation of a storyboard that outlines the sequence of the material, which is then elaborated and integrated into the e-module prototype.
2) Production: This stage aims to develop the product according to the prototype that has been validated by experts. The e-module is developed based on the needs analysis conducted at Universitas Negeri Malang with students who have taken the Plant Physiology course. The content includes plant cells and water, water balance, and nutrition and nutrient transport. The development of this interactive e-module design focuses on SDGs, particularly SDG 2.4, based on the PBL model.

3) Post-Production: This stage aims to revise the created product and align it with the prototype that was developed. Product validation is conducted by media and subject matter experts. Practicality testing is carried out by field practitioners and students with specific qualifications. The qualifications are presented in Table 3:

Table 3. Validator Qualifications

No.	Validator	Qualification
1	Subject Matter Expert	A lecturer from the Biology Education program with a minimum of a Master's degree and at least 5 years of teaching experience.
2	Media and Instructional Material Expert	A lecturer from the Biology Education program with expertise in the development and preparation of teaching materials, with at least 5 years of teaching experience.
3	Biology Education Practitioner	A lecturer teaching Plant Physiology with a minimum of a Master's degree and at least 5 years of teaching experience in the field.

The data collection technique for the e-module feasibility test is conducted through a validation questionnaire involving three types of experts: subject matter experts, media experts, and learning tool experts. This questionnaire is specifically designed to evaluate the feasibility of the product in each of these areas, with questions that are relevant and specific to each aspect. The validation questionnaire instrument uses a Likert scale consisting of five evaluation categories: (a) Score 5: Very Good, (b) Score 4: Good, (c) Score 3: Fairly Good, (d) Score 2: Poor, and (e) Score 1: Not Good. This scale aims to provide a more detailed picture of how well the e-module meets the expected criteria in terms of content, media design, and the feasibility of the learning tools used. After data collection, the results from the validation questionnaire are analyzed using descriptive quantitative analysis to provide an overall evaluation of the results. The data analyzed includes assessments given by the subject matter experts, media experts, and learning tool experts, each providing a specific perspective on the quality of the e-module. Based on the procedures carried out in the e-module validity test, the obtained data is then presented using the Likert scale and analyzed descriptively. The validity criteria for the e-module are then analyzed with the following calculation:

$$V = \frac{TSe}{TSh}\ x\ 100\%$$

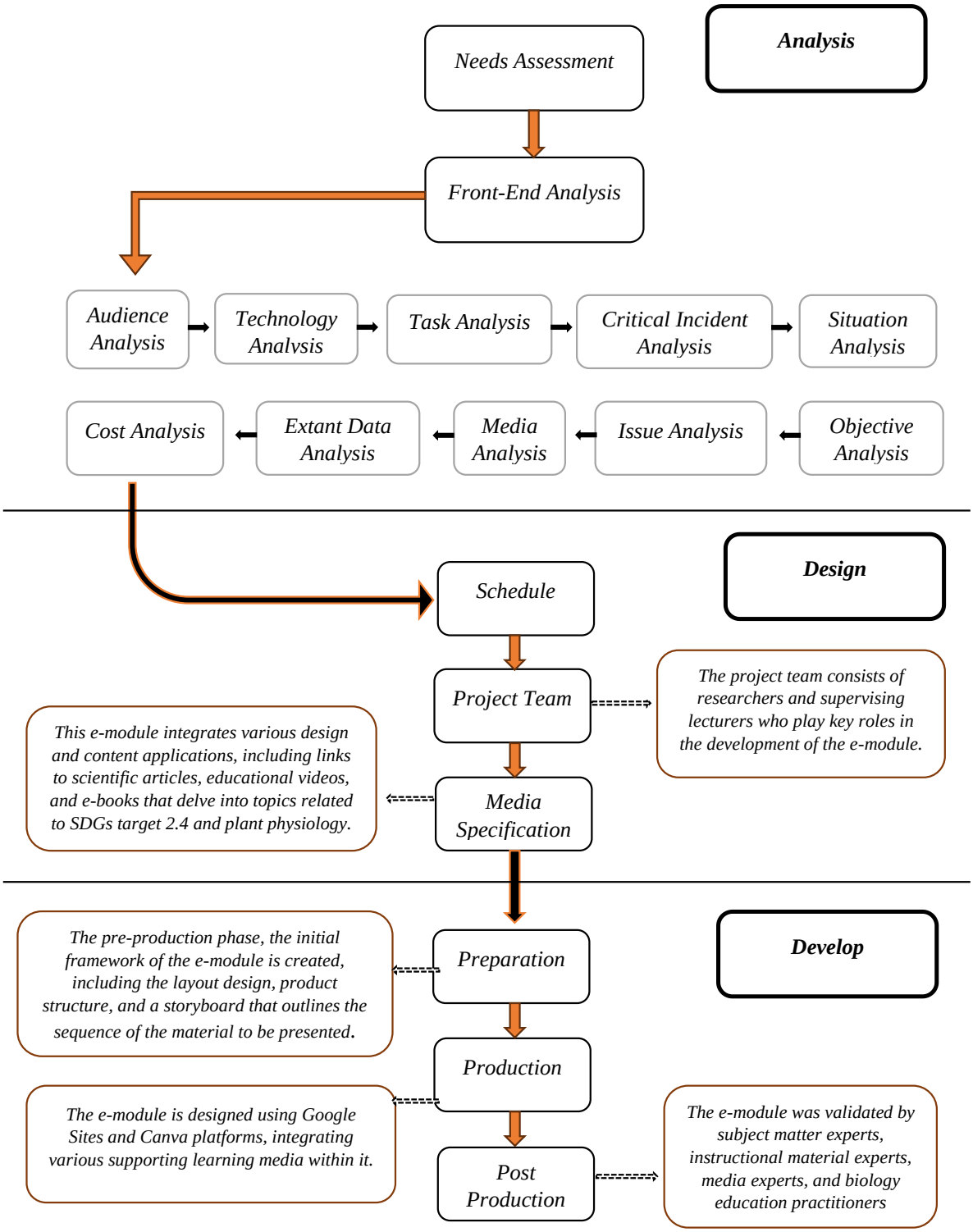
Description:
v : product validity percentage
Tse : total evaluation score
TSh : total maximum score

The assessment of this feasibility test can be interpreted based on the criteria listed in Table 4, which provides an in-depth overview of the e-module's feasibility level according to the scores given by the validators. This can serve as a reference for further revisions and development.

Table 4. E-Module Validity Criteria

Percentage (%)	Category	Description
85.00 ≤ X	Highly Feasible	Minor revisions required
70.00 ≤ X < 85.00	Feasible	Major revisions required
55.00 ≤ X < 70.00	Less Feasible	Not suitable for use
40.00 ≤ X < 55.00	Not Feasible	Not suitable for use
X < 40.00	Highly Unfeasible	Not suitable for use

Figure 1. E-Module Development Process Flow



RESULT AND DISCUSSION

The development process resulted in an interactive electronic module (e-module) that integrates the principles of the Sustainable Development Goals (SDGs), with a focus on SDG 2.4, through the Problem-Based Learning (PBL) model. This e-module was developed using integrated digital platforms, namely Google Sites and Canva, which allow for engaging interactive designs that are easily accessible to users. The e-module is designed to provide a deeper learning experience by integrating various resources and supportive learning media. Key elements include educational videos explaining topics related to SDG 2.4, links to relevant

scientific articles, and access to Google Drive, which provides supporting documents for students. Additionally, evaluation and feedback from students are facilitated through the use of Google Forms, enabling systematic and efficient data collection. The creation of this e-module aims to develop a learning platform that is not only interactive but also supports the development of students' ownership of learning skills in the context of SDGs. This e-module is designed to encourage students to take a more active role in managing their learning process, develop a sense of responsibility toward the material being studied, and enhance their ability to explore and manage learning independently. The final design of the e-module can be seen in Figure 2 below.

(1) Initial display of the e-module

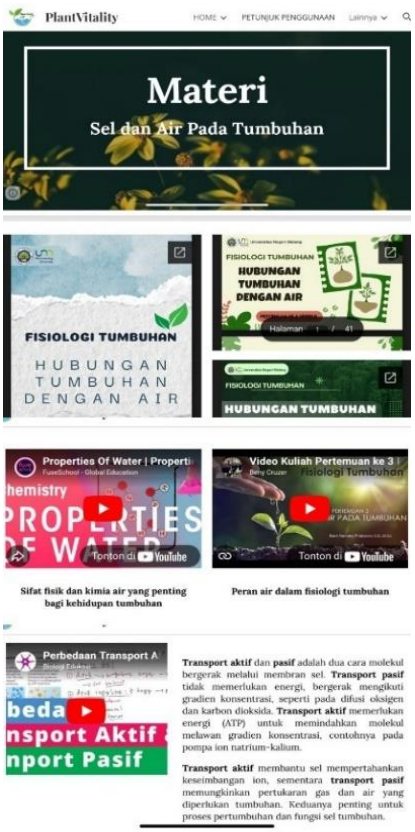
(2) Homepage display

(3) User instructions page display

(4) Learning Activity Menu

(5) Learning Activity Menu

(6) Student Worksheet (LKM) Menu



(7) Material Menu

(8) Discussion column menu

(9) Developer profile page

(10) Evaluation menu

(11) Pre- and post-reflection menu

(12) Assessment rubric menu

Figure 2. E-module Creation Results

Results of the Subject Matter Expert Feasibility Test and Learning Tools

Results of the Subject Matter Expert Feasibility Test

The material feasibility test process is conducted to assess various aspects, including the fulfillment of content requirements (norms), alignment with the curriculum, accuracy based on scientific principles, relevance to the curriculum, its connection to real-world contexts and issues, and the coherence between different sections of the material. Additionally, the standards of presentation and language usage are also evaluated. The material feasibility test was conducted twice. In the first feasibility test, the percentage score from the expert was 96.57%,

which falls into the highly feasible category. However, this result still needs improvement to achieve an average percentage score of 100%. The material feasibility test must achieve the highest score related to the learning activities, as the core of the knowledge delivery process, ensuring its validity is flawless. The summary of the e-module feasibility test results by subject matter experts before the revision can be seen in Table 5, and after the revision in Table 6 below.

Table 5. Summary of Subject Matter Expert Validation Results Before Revision

	Evaluation Aspect	Percentage (%)	Category
	Content Requirements:		
	a. Legality	100	Highly Feasible
a.	b. Norms	100	Highly Feasible
	Content Feasibility:		
	a. Alignment with the curriculum	86.6	Highly Feasible
	b. Scientific accuracy	98.57	Highly Feasible
	c. Alignment with the applicable curriculum	98.18	Highly Feasible
	d. Relevance to real-world contexts and issues	93.33	Highly Feasible
	e. Coherence between sections of the content	100	Highly Feasible
	Presentation Standards:	92.5	Highly Feasible
	Language Standards:	100	Highly Feasible
	Overall Average Percentage:	96.57	Highly Feasible

Table 6. Summary of Subject Matter Expert Validation Results After Revision

	Evaluation Aspect	Percentage (%)	Category
	Content Requirements:		
	a. Legality	100	Highly Feasible
b.	b. Norms	100	Highly Feasible
	Content Feasibility:		
	a. Alignment with the curriculum	100	Highly Feasible
	b. Scientific accuracy	100	Highly Feasible
	c. Alignment with the applicable curriculum	100	Highly Feasible
	d. Relevance to real-world contexts and issues	100	Highly Feasible
	e. Coherence between sections of the content	100	Highly Feasible
	Presentation Standards:	100	Highly Feasible
	Language Standards:	100	Highly Feasible
	Overall Average Percentage:	100	Highly Feasible

Based on the summary of the material feasibility test results after revision, as shown in Table 6, the final score of the material feasibility test is 100%, which falls into the highly feasible category and is ready for use without further revisions. The feasibility test of the material in the media must cover aspects of feasibility that are not only accurate but also relevant to students' needs. Learning activities, as the core of the knowledge delivery process, must align with the applicable curriculum to ensure the optimal achievement of learning objectives. Additionally, the learning material must be a central element in the learning process, making it essential to ensure that the material designed aligns with relevant academic contexts and contains up-to-date information that is beneficial for students. Suggestions and improvements related to the material feasibility test results can be seen in Table 7 below.

Table 7. Suggestions and Improvements from Subject Matter Expert Validation

No	Comments and Suggestions
1	Add the following incomplete materials: a. The relationship between plants and the environment from: atmosphere, lithosphere, and hydrosphere b. Factors affecting water absorption in plants c. The mechanism of translocation of materials and energy in plant cells d. Differences in mechanisms, locations, and times between transpiration, evaporation, and guttation e. Factors affecting transpiration in plants f. The mechanism of water deficiency and tolerance in plants g. The difference in types of planting media and their relation to water and nutrient mechanisms in plants
2	Add content in the third section related to deficiencies and toxicity phenomena in society.
3	Add a stomata image and a video on the mechanism of stomata opening and closing in lesson 2.
4	Complete the material on nutrients by including the 19 macro and micronutrients.
5	In lesson 3, there is an image and description that are not appropriate, particularly in the image showing deficiency or hunger in plants.
6	On the learning activity page, the initial page displaying the material description, LKM, TP, video lessons, and activities 1, 2, and 3 cannot be clicked but are on the next page. This may cause confusion for users, as the initial page appears like clickable tools for learning stages. Please revise and adjust to avoid user confusion.
7	In PPT/Canva for lesson 3, the highlighted material title should be about plant nutrition and nutrient transport.

The revision of the material is crucial to produce accurate and appropriate teaching resources, ensuring that students gain a comprehensive understanding. This revision process aims to ensure that the material is not only scientifically valid but also aligned with the latest developments in the field. Based on the results of the material feasibility test, it can be concluded that this e-module meets the established quality standards and is ready to be used as an effective learning tool.

Results of the Learning Tools Feasibility Test

The feasibility test of learning tools aims to assess the suitability and validity of the tools to be used in the learning process, ensuring they meet the established standards. The

learning tools evaluated by experts include the Semester Learning Plan (RPS), which is assessed to ensure the balance of time allocation, learning outcomes, and objectives that align with the curriculum. Next, the Learning Session Plan (SAP) is evaluated based on its alignment with learning objectives, the relevance of the content to real-world issues, and the development of students' ownership of learning skills. The e-module is assessed for completeness of identity, curriculum alignment, and the application of the Problem-Based Learning (PBL) model. The Student Worksheet (LKM) is also evaluated to ensure that students can collaborate and reflect on their learning. The ownership of learning skills instrument evaluates students' independence and motivation in learning. This feasibility test ensures that the learning tools can support the achievement of the desired competencies.

Table 8. Summary of Learning Tools Results

Evaluation Aspect	Percentage (%)	Category
Learning Session Plan (SAP):		
a. Completeness and alignment with learning objectives	100	Highly Feasible
b. Clarity and content of learning objectives	100	Highly Feasible
c. Relevance to real-life and time allocation	95	Highly Feasible
d. Development of students' ownership of learning	100	Highly Feasible
Plant Physiology E-module:		
a. General components	100	Highly Feasible
b. Core components	100	Highly Feasible
c. Development of ownership of learning	100	Highly Feasible
d. Assessment	100	Highly Feasible
Student Worksheet (LKM):	98	Highly Feasible
Language Standards:	100	Highly Feasible
Benefits:	100	Highly Feasible
Ownership of Learning Instrument:		
a. Content accuracy	100	Highly Feasible
b. Relevance	100	Highly Feasible
c. Measurement of student understanding	100	Highly Feasible
d. Alignment with ownership of learning indicators	96	Highly Feasible
Overall Average Percentage:	99	Highly Feasible

Based on the summary of the feasibility test results for the learning tools, which include the Learning Session Plan (SAP), plant physiology e-module, Student Worksheet (LKM), and ownership of learning instrument, the final average percentage obtained is 99%, placing the learning tools in the highly feasible category. All evaluated aspects, including the completeness of learning objectives, relevance to real-life, development of students' ownership of learning, as well as the components of the e-module and assessment, have met the highly feasible standards. Based on the feasibility test results, these learning tools are considered highly feasible and can be used with minor revisions. Suggestions from the validators that should be considered as the basis for revisions are outlined in Table 9.

Table 9. Suggestions and Revisions of Learning Tools

No	Comments and Suggestions	
	Revision	**Revision**
1.	The time allocation is in line with the semester program, learning outcomes, and learning objectives. However, based on the SAP, it reaches up to the 11th meeting, and in the RPS, it ends before the midterm (up to the 8th meeting), for achieving 2 sub-CPMKs, while the total sub-CPMKs are 9. Therefore, it needs to be reexamined for time allocation balance to ensure that all sub-CPMKs receive nearly equal time distribution, without significant differences.	After reviewing the time allocation in the Learning Session Plan (SAP) and the Semester Learning Plan (RPS), improvements have been made to ensure a more balanced distribution of time between each sub-CPMK. In this revision, the time allocation has been adjusted to ensure a more even and proportional distribution, making sure that each sub-CPMK receives sufficient time for optimal achievement.
2.	It is already aligned, but it would be better to add a graph containing certain data and have students analyze it. This will help sharpen students' critical thinking.	A graph has been provided in the article attached to the Student Worksheet (LKM).
3.	Use the term "learning strategy" instead of "teaching strategy" in the questionnaire, as it refers to an individual approach, not for the classroom or teacher context.	In the questionnaire, the term "learning strategy" has been replaced with "teaching strategy" to better reflect the individual context, rather than the classroom or teacher-centered approach.

Expert Media Feasibility Test Results

The feasibility test of the e-module by media validators includes various evaluation components to ensure its quality and effectiveness in supporting learning. The aspects assessed include design, which encompasses technical quality and communication to make the content easy to understand and effective. The evaluation also includes graphics, which assess the visual appearance of the e-module, as well as the module characteristics, such as self-instructional, self-contained, stand-alone, adaptive, and user-friendly, which ensure that the e-module can be used independently, completely, autonomously, and flexibly for various student learning styles. The media feasibility test was conducted twice. The first feasibility test obtained a final percentage of 88.66%, which falls under the highly feasible category, but still required revisions. Revisions were made based on suggestions and feedback from experts to ensure the e-module met the "highly feasible" category with a note that it was ready for use without further revisions. A summary of the e-module media feasibility test results before the revision can be seen in Table 10, and after the revision in Table 11 below.

Table 10. Summary of Media Expert Validation Results Before Revision

Evaluation Aspect	Percentage (%)	Category
Design Aspect	90.52	Highly Feasible
Graphics Aspect	80	Feasible
E-module Characteristics:		
a. Self-instructional	97.5	Highly Feasible
b. Self-contained	95	Highly Feasible
c. Stand-alone	96	Highly Feasible

Evaluation Aspect	Percentage (%)	Category
d. Adaptive	93.33	Highly Feasible
e. User-friendly	96	Highly Feasible
Overall Average Percentage	92.62	Highly Feasible

Table 11. Summary of Media Expert Validation Results After Revision

Evaluation Aspect	Percentage (%)	Category
Design Aspect	98	Highly Feasible
Graphics Aspect	100	Highly Feasible
E-module Characteristics:		
a. Self-instructional	100	Highly Feasible
b. Self-contained	100	Highly Feasible
c. Stand-alone	100	Highly Feasible
d. Adaptive	100	Highly Feasible
e. User-friendly	100	Highly Feasible
Overall Average Percentage	99,71	Highly Feasible

Based on the results of the media feasibility test summary after revision shown in Table 10, an overall score of 99.71% was achieved, indicating that the e-module has a very high feasibility level and only requires minor improvements before it can be used. The revisions made demonstrate that the e-module is ready for implementation in the learning process. Suggestions from media expert validators that should be considered for further improvements include the introductory video display, font usage, and mobile screen display. The researcher has made improvements to these components in the e-module with SDGs target 2.4 PBL content to enhance its quality in accordance with the comments and feedback from media experts. The comments and suggestions can be seen in Table 12 below.

Table 12. Suggestions and Improvements for Learning Media

No	Comments and Suggestions	
	Revision	Revised Results
1.	The use of fonts should be limited to a maximum of three types to improve consistency and display comfort.	The font usage has been adjusted to a maximum of three types to create a more consistent and readable display.
2.	The display on mobile phones is still cut off; it should be improved to make it more responsive and adapt to the screen size.	The display on mobile phones has been improved so that no parts are cut off.
3.	The number of moving images in the e-module should be reduced, as too many moving images can cause the e-module to load slowly.	The number of moving images in the e-module has been reduced to improve loading speed.

Results of the Feasibility Test by Biology Education Practitioners

Biology education practitioners play a role as validators with a deep understanding of classroom learning activities. The feasibility test conducted by the Plant Physiology course lecturer at Universitas Negeri Malang, who has over ten years of teaching experience, ensures that the assessment results obtained are accurate and valid. The feasibility test of the e-module includes several components: content feasibility, presentation, language, design and graphics,

and usability. A summary of the e-module feasibility test results by biology education practitioners can be seen in Table 13.

Table 13. Summary of Biology Education Practitioners' Validation Results

Evaluation Aspect	Percentage (%)	Category
Content Feasibility	92.9	Highly Feasible
Presentation Aspect	97.5	Highly Feasible
Language Standards	100	Highly Feasible
Design and Graphics	97.1	Highly Feasible
Usability	100	Highly Feasible
Average Percentage	97.5	Highly Feasible

Based on the summary of the biology education feasibility test results presented in Table 13, the final percentage score of 97.5% was obtained, indicating that the e-module has a very high feasibility level and can be used with only minor revisions. According to the feasibility test results from subject matter experts, media experts, learning tool validators, and biology education practitioners, the developed e-module is generally considered highly feasible. This is reflected in the final percentage score, which meets the high feasibility criteria in all assessment aspects, indicating an excellent feasibility level. These results suggest that the SDGs target 2.4-based PBL e-module is suitable for use in the learning process and can be implemented in the next stage without major revisions.

Discussion

SDGs target 2.4 based on Problem-Based Learning for ownership of learning skills. This e-module was developed using the development model by Carrió Llach & Llerena Bastida, (2023). The e-module is aligned with content discussing the relationship between water and plants. The material consists of three subtopics: Cells and Water in Plants, Water Balance in Plant Bodies, and Nutrition and Nutrient Transport in Plants, which are taught in the Plant Physiology course at the Department of Biology, Universitas Negeri Malang. The e-module, which integrates SDGs target 2.4 and Problem-Based Learning, has undergone a feasibility test by a number of validators with relevant expertise, including subject matter experts, educational tools, media specialists, and Biology Education practitioners. The results of the feasibility test indicate a high level of feasibility, both in terms of the content substance and the technical aspects of media usage.

Feasibility test by subject matter experts

The feasibility test of the material is conducted to evaluate various aspects, such as alignment with the curriculum, scientific accuracy, relevance to real-world contexts, and coherence among the different sections of the material. Additionally, the evaluation includes presentation standards and the use of clear language to ensure material comprehension. The developed e-module must meet high feasibility standards to ensure that the information presented is accurate and easy to understand. High feasibility supports effective learning and prevents misconceptions that could hinder students' understanding, particularly for prospective teachers. This aligns with Gogahu & Prasetyo (2020) who emphasize the importance of validation by subject matter experts to ensure conceptual alignment. After revisions based on validator feedback, the final result of the material feasibility test achieved 100% (highly feasible). This percentage indicates that the revised material meets all feasibility criteria, including curriculum alignment, scientific accuracy, presentation quality, and clear language usage. Feasible and high-quality material will enrich students' knowledge and enhance the overall quality of education. This is in line with the findings of Raibowo *et al*.,

(2020) which show that valid and high-quality teaching materials, particularly those integrating multimedia, can improve the learning experience, facilitate access to information, and enrich students' understanding while motivating learning.

The integration of material plays a significant role in the effectiveness of learning, where suitable material can positively impact students' ownership of learning skills, including responsibility and active involvement in learning. Appropriate and high-quality material motivates students to manage, direct, and evaluate their learning independently, which in turn improves their understanding and academic achievement. These results are consistent with the findings of Nur'ainy, (2025) who states that e-modules help students learn independently by providing structured and easy-to-understand material. Interactive features like quizzes and videos encourage students to plan, monitor, and evaluate their learning process, which can enhance learning outcomes.

Feasibility test by learning materials experts

The feasibility test of the learning tools conducted by experts includes an evaluation of the Semester Learning Plan (RPS) to ensure the balance of time allocation, learning outcomes, and objectives in line with the curriculum. Furthermore, the Learning Session Plan (SAP) is evaluated based on its alignment with learning objectives, the relevance of the content to real-world issues, and the development of students' ownership of learning skills. The e-module is assessed for completeness of identity, curriculum alignment, and the application of the Problem-Based Learning model. The Student Worksheet (LKM) is evaluated to ensure collaboration and reflection in learning. The ownership of learning skills instrument assesses students' independence and motivation in learning. This is in line with Latif *et al*., (2022) who state that the feasibility test of learning tools aims to ensure the validity of learning tools through expert evaluations.

The results of the feasibility test for the RPS and SAP reached 99%, indicating that the tools are highly feasible with only minor revisions, especially concerning relevance to daily life and time allocation, which scored 95%. Expert suggestions for improvement include balancing the time distribution between the RPS and SAP to ensure effective learning without rushing any material. This revision will optimize the learning tools. This is in line with Yusnaldi *et al*., (2024) who emphasize the importance of balancing time allocation to optimize learning. The results of the feasibility test for the plant physiology e-module reached 100%, indicating that all elements, including identity completeness, curriculum alignment, and the application of the Problem-Based Learning (PBL) model, met highly valid criteria. The results of the feasibility test for the Student Worksheet (LKM) reached 98%, indicating that the LKM is very valid, although it still requires slight improvements. The suggestion provided is to add graphs with specific data for group analysis, which will enhance students' critical thinking and collaboration skills. This aligns with the findings of Wardani *et al*., (2026) which indicate that E-LKM can facilitate active student engagement and the development of analytical skills.

The results of the feasibility test for language standards and benefits reached 100%, showing that these aspects are highly valid. The language in the learning tools is clear and easy to understand, while the benefits have a significant positive impact on students. Both aspects meet the standards and do not require further revisions. The results of the feasibility test for the ownership of learning instrument obtained 99%, indicating that this instrument is highly valid. All aspects, including content accuracy, relevance, and measurement of student understanding, scored 100%, but in terms of alignment with ownership of learning indicators, it received 96%, with the suggestion to replace the term "learning strategy" with "learning strategies" to better suit the pedagogical context.

Feasibility test by media experts

The developed e-module for the Plant Physiology course underwent a feasibility test by validators who are experts in media and instructional materials. The aspects tested included

design, technical quality, communication, graphics, and module characteristics such as self-instructional, self-contained, stand-alone, adaptive, and user-friendly, ensuring that the e-module is usable independently, comprehensive, and flexible for various learning styles. Rohimah & Faizah, (2025) It is stated that an e-module with good technical quality can enhance students' understanding and motivate them to engage more actively in learning, as well as achieve learning objectives more effectively. The expert media feasibility test results after revision showed an average validity score of 99.71% (very feasible), indicating that the e-module meets high validity standards and is effective in supporting student interaction in learning. This is in line with the view of Syamsussabri, (2019) states that effective teaching materials must be able to accommodate interaction and active student engagement. Kosasih, (2021) adds that e-modules should have characteristics such as self-instructional, self-contained, stand-alone, adaptive, and user-friendly to ensure ease of use and independent learning.

The feasibility study of the e-module shows that its self-instructional characteristics enable students to learn independently with structured content, easy navigation, as well as videos, quizzes, and exercises that support understanding and learning motivation. These features also enhance ownership of learning. This aligns with the findings of Rahayu, N. D., *et al*., (2025) which indicate that features in the e-module, such as multimedia and quizzes, help students regulate their learning pace and strengthen metacognition and motivation. The self-contained characteristic ensures that the e-module can be used independently without relying on external sources. This e-module includes comprehensive content on the relationship between plants and water, supporting SDGs 2.4, and is equipped with videos, quizzes, and exercises that enrich understanding. These findings are consistent with the results of Rahayu, N. D., *et al*., (2025) who stated that features like quizzes and videos enhance students' learning independence. The stand-alone characteristic means that the e-module can be used without direct interaction with the instructor. Features such as complete material, easy navigation, and clear instructions allow students to learn flexibly at their own pace. This supports independent learning and boosts students' confidence in mastering the material, as stated by Farawansah, (2022).

The adaptive characteristic shows that the e-module can be updated in accordance with the latest developments in knowledge and technology. This e-module integrates SDGs 2.4 and includes the latest scientific articles on sustainable agriculture, making it relevant to students' needs. This is in line with the opinion of (Kosasih, 2021) who stated that e-modules should be able to adjust content according to current advancements. The user-friendly characteristic ensures that the e-module is designed according to students' interests and needs, with easy navigation, an appealing design, and clearly organized content. Features such as clear navigation buttons and readable fonts enhance user comfort and learning effectiveness, in accordance with the findings of Ardianti *et al*., (2025) which indicate that interactive e-modules support self-regulated learning.

Feasibility Test by Biology Education Practitioners

The feasibility test conducted by biology education practitioners was carried out on several aspects, such as the content feasibility, presentation, language standards, design and graphics, as well as usability (Nadira *et al*., 2022). Each of these aspects ensures that the learning device is suitable for use and can optimally support the achievement of learning objectives. The content feasibility aspect assesses the alignment of the material with learning outcomes, accuracy of concepts, depth of content, as well as its relevance to the curriculum and student needs. The presentation aspect evaluates the systematics, clarity of flow, and coherence between objectives, material, activities, and assessments. The language standards aspect ensures that the language used is communicative, follows the rules, and is easy to understand. The design and graphics aspect refers to the visual appearance, layout, font selection, and use of illustrations that support the understanding of the material. The usability aspect evaluates

the ease of use, effectiveness, and flexibility of the e-module in facilitating effective and efficient learning.

The feasibility test results by biology education practitioners showed a percentage of 97.5% (very feasible), indicating that the learning instrument meets excellent standards. The content feasibility aspect scored 92.9%, assessing the alignment of the material with learning objectives and basic competencies. The presentation aspect scored 97.5%, indicating systematic and clear presentation of the material. The language standards aspect scored 100%, reflecting the use of language that adheres to correct and proper Indonesian language rules. The design and graphics aspect scored 97.1%, indicating visual elements that support material comprehension. The usability aspect also scored 100%, showing that this e-module is very practical and beneficial for learning. The e-module, which contains SDGs target 2.4 PBL, is considered highly feasible as an effective and quality learning aid. These findings align with Manzil & Thohir, (2022), which states that the positive responses from teachers and the high validity values indicate that this e-module is highly suitable for use.

CONCLUSION

The development and feasibility testing of an e-module integrating SDGs Target 2.4 based on Problem-Based Learning (PBL) for ownership of learning skills in biology education have been successfully carried out. The e-module, designed for the course of Plant Physiology, has undergone various validation stages by subject matter experts, instructional media experts, and biology education practitioners. The results of the evaluation indicate that the e-module is highly valid, signifying that it is ready for use in learning activities. This e-module is effective in integrating key features such as multimedia, quizzes, and clear navigation, which promote active student engagement and independent learning. The e-module provides a flexible and self-directed learning experience, ensuring that students can explore and engage with the material at their own pace. These findings suggest that digital tools such as e-modules can significantly enhance student engagement and motivation, making learning more effective and relevant to real-world challenges. Future research can focus on expanding the application of e-modules to other courses and disciplines, particularly those related to global challenges such as climate change and sustainable development.

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