

VALIDITY OF INTERACTIVE E-MODULES ON PLANT GROWTH AND DEVELOPMENT TO TRAIN STUDENTS' SCIENCE LITERACY SKILLS

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Abstract

Science literacy is the ability to think scientifically to solve problems and is one of the essential 21st-century skills. However, students' science literacy in Indonesia remains relatively low and is not yet optimally trained in learning activities. One effort to improve this skill is through the development of interactive e-modules as learning materials. This study aims to develop a valid interactive e-module on plant growth and development to train students' science literacy skills. The research consists of three stages: observation, design, and validity assessment. Validity was reviewed by media and subject matter experts using a validation instrument covering presentation, content, and language aspects, assessed on a 4-point Likert scale (1 = not valid to 4 = very valid). The results were analyzed using Aiken's V to determine the level of agreement among validators. The developed e-module contains features such as Go Search, Go Wonder, Go Plan, and Go Found, which are integrated with science literacy indicators. The average Aiken index for all aspects was 1.00, indicating a high level of validity. Based on the findings, the interactive e-module is considered valid and feasible to be used as a teaching material to support the development of science literacy skills in high school students.

Keywords: Validity, Interactive E-Module, Science Literacy Skills, Plant Growth and Development.

Abstrak

Keterampilan literasi sains merupakan keterampilan yang mengedepankan kemampuan berpikir secara ilmiah dalam memecahkan suatu masalah. Keterampilan ini menjadi salah satu keterampilan yang harus dikuasai oleh peserta didik pada abad ke-21, namun literasi sains peserta didik di Indonesia masih tergolong rendah dan belum dilatihkan secara optimal dalam kegiatan pembelajaran. Upaya melatih keterampilan literasi sains dapat dilakukan dengan pengembangan E-Modul interaktif sebagai bahan ajar peserta didik. Penelitian ini bertujuan menghasilkan E-Modul interaktif materi pertumbuhan dan perkembangan tumbuhan untuk melatih keterampilan literasi sains peserta didik yang layak berdasarkan validitas. Prosedur penelitian terdiri dari tiga tahap yaitu observasi, perancangan dan penilaian validitas. Kelayakan E-Modul interaktif diperoleh dari dosen ahli media dan materi meliputi telaah dan penilaian validitas menggunakan instrumen validasi yang mencakup aspek penyajian, isi dan kebahasaan dengan penilaian skala Likert 4 poin, 1-4 (kurang baik-sangat baik). Data penilaian selanjutnya dianalisis secara statistik melalui perhitungan indeks validitas Aiken untuk mengukur tingkat kesepakatan para ahli terhadap kelayakan isi E-Modul berdasarkan aspek yang dinilai. Hasil penelitian berupa pengembangan bahan ajar E-Modul interaktif dengan indeks validitas penyajian, isi dan kebahasaan masing-masing memperoleh nilai indeks Aiken 1. Secara keseluruhan, indeks validitas Aiken berdasarkan ketiga aspek memperoleh rata-rata nilai sebesar 1 yang artinya E-Modul memiliki validitas tinggi. Berdasarkan hasil penelitian dapat disimpulkan bahwa E-Modul interaktif materi pertumbuhan dan perkembangan tumbuhan untuk melatih keterampilan literasi sains peserta didik layak diterapkan ditinjau dari validitas.

Kata Kunci: Validitas, E-Modul Interaktif, Keterampilan Literasi Sains, Pertumbuhan dan Perkembangan Tumbuhan.

INTRODUCTION

Education serves as the primary means to develop individual abilities in order to play a role in society (Pratomo & Herlambang, 2021). Entering the era of 21st-century education, the Indonesian government has implemented the “Merdeka Curriculum” policy to achieve 21st-century education competencies and to prepare students to face increasingly complex future challenges. One of the objectives of the Merdeka Curriculum is to enhance literacy as both a student character trait and a core competency. There are six basic literacy components, including reading-writing-arithmetic, scientific literacy, information and communication technology literacy, financial literacy, cultural literacy, and civic literacy (Kemendikbud, 2016). Among these, scientific literacy is a crucial skill for addressing the challenges of the 21st century.

Scientific literacy is essential for students in order to keep up with the rapid advancement of science and technology, as it emphasizes the ability to think scientifically when solving problems. According to OECD (2000), scientific literacy refers to the ability to apply knowledge to identify issues and draw conclusions based on data and facts, thereby enabling individuals to understand and respond to real-world phenomena. Students’ scientific literacy skills are reflected in three core competencies: explaining scientific phenomena, evaluating and designing scientific investigations, and interpreting data and evidence scientifically (OECD, 2017).

Based on data from the Programme for International Student Assessment (PISA) in 2022, Indonesia’s scientific literacy score remains low, particularly in science, which reached only 359 compared to the global average of 476 (OECD, 2022). National literacy data in 2024 show that the literacy achievement of general senior high school students stands at 70.3% (Kemendikbudristek, 2024). Observations at one senior high school in Surabaya also revealed that students’ scientific literacy skills were at 57.90%, indicating room for improvement.

The underdeveloped scientific literacy skills of students are influenced by several factors, including teaching and learning processes that do not foster independent problem-solving and a lack of varied learning resources. Teachers also contribute to this issue, as the learning process is often not linked to scientific literacy, making it difficult for students (Hidayah *et al.*, 2019). Suparta *et al.* (2022) state that the over-reliance on textbooks as learning resources limits students’ ability to

connect the subject matter to real-life phenomena—an important aspect of scientific literacy. A potential solution to train students’ scientific literacy skills is to make optimal use of learning resources such as interactive E-Modules (Raharjo *et al.*, 2017).

E-Module is an electronic form of a module that includes learning objectives, content explanations, independent activities, evaluation questions, summaries, and reflections. It is designed to support self-directed learning, enabling students to learn at their own pace and in accordance with their learning styles without fully relying on the teacher’s presence (Prastowo, 2015). According to Prastiwi *et al.* (2019), digital media such as E-Modules are effective for assessing and fostering scientific literacy skills because they allow students to conduct experiments, analyze data, engage in scientific communication, and reflect independently. An E-Module is considered interactive when it includes supporting media such as videos, images, and texts that allow users to interact with the learning content, assist with navigation, and include feedback from the teacher (Pramana *et al.*, 2020).

Interactive E-Modules are well-suited for training students’ scientific literacy skills, as they help students independently identify the competencies they need to improve in order to achieve learning goals (Lastri, 2023). Faridah *et al.* (2020) found that the use of interactive E-Modules is effective for training scientific literacy skills, as shown by an achievement rate of 89% for literacy indicators (categorized as very good). Another study by Awwalina and Indana (2022) reported that interactive E-Modules improve students’ concept mastery, with a feasibility rating of 97.75%. The interactivity feature in E-Modules increases students’ interest in learning materials.

Scientific literacy skills are essential in science-related subjects such as biology (Nofiana, 2018). The topic of plant growth and development covers the processes and influencing factors of plant growth, which have implications for other living organisms (Arimbawa, 2016). This topic has practical relevance to daily life and involves explaining biological processes that affect the environment. Under the Merdeka Curriculum, the topic of plant growth and development is part of Phase F Learning Outcomes, where students are expected to apply concepts related to growth and development in plants. According to Handayani *et al.* (2018), this topic requires not only theoretical understanding but also problem-solving skills relevant to everyday life through process skills that are closely linked to scientific literacy. However, current biology teaching still relies on instructional materials that

do not integrate scientific literacy indicators. Research by Imaningtyas *et al.* (2016) shows that effective biology instruction is achieved by connecting scientific concepts to real-world phenomena, which can be facilitated by integrating scientific literacy indicators into learning materials.

Based on the problems described above, this study aims to develop an interactive E-Module on plant growth and development to train students' scientific literacy skills, with a focus on its validity.

METHOD

This research is a descriptive study. It describes the validity of an interactive E-Module on plant growth and development to train students' scientific literacy skills. The validity results are used to determine the feasibility of implementing the E-Module in classroom learning. The interactive E-Module was developed using the Canva application and then converted into a website using Heyzine.

The research procedure consisted of three stages: observation, design, and validity assessment. Based on the observation results, it was found that learning activities on the topic of plant growth and development did not yet actively involve students and had not optimally trained their scientific literacy skills. Moreover, there were no interactive learning materials available that integrated the seven indicators of scientific literacy skills.

The interactive E-Module was developed based on the Merdeka Curriculum, specifically the Learning Outcomes for Phase F, in which students are expected to apply concepts related to plant growth and development. The materials presented in the E-Module are divided into two main topics: (1) the stages of plant growth and development, and (2) the factors influencing plant growth and development.

The interactive E-Module is designed to train the scientific literacy skills of 11th-grade senior high school students. The targeted scientific literacy skills include identifying scientific phenomena, formulating hypotheses, generating questions, designing solutions to problems, converting data from one form to another, analyzing data, and drawing conclusions (OECD, 2017).

The research was conducted in the Biology Education Undergraduate Program from January to May 2025. Data were obtained through a validation method carried out by two validators, consisting of a media expert and a subject matter expert. The product was evaluated using a validation sheet with a Likert scale ranging from 1 to 4. A score of 1 indicates "not valid," 2 indicates "fairly valid,"

3 indicates "valid," and 4 indicates "very valid" (Riduwan, 2016). The validation scores from the two expert validators were then averaged to determine the overall level of validity of the E-Module.

To further assess the level of agreement between validators and the validity of the E-Module, Aiken's formula was used as follows.

$$V = \frac{\sum s}{n(c-1)} \dots (2)$$

Keterangan:

- V : Raters' agreement index on item validity
- s : The score given by the rater minus the lowest possible score ($s = r - Lo$)
- r : The score given by the rater
- Lo : Lowest rating score (1)
- n : Numbers of raters (2)
- c : Highest rating score (4)

The Aiken index values were then classified into validity levels according to the categorization proposed by Hsu *et al.* (2015) (Table 1).

Table 1. Validity Categories Based on Aiken's Index

Index	Kategori Validitas
0,71 – 1,00	High
0,30 – 0,70	Moderate
0,00 – 0,30	Low

The validity results are used to determine the feasibility of implementing the E-Module in classroom learning. Based on the criteria in Table 1, the interactive - E-Module is considered to have high validity if it obtains an Aiken's index of ≥ 0.70 .

RESULT AND DISCUSSION

The result of this study is an interactive E-Module on the topic of plant growth and development, developed to train students' scientific literacy skills and deemed feasible based on its validity. The developed E-Module consists of 50 pages and can be accessed via the Heyzine website using a smartphone, laptop, or computer connected to the internet. Heyzine was chosen because it is user-friendly, accessible without requiring additional applications, and features engaging elements such as animations, images, videos, and audio (Kismawati *et al.*, 2022).

The developed E-Module is integrated with scientific literacy skill indicators, including identifying scientific phenomena, formulating hypotheses, generating questions, designing solutions to problems, transforming

data from one form to another, analyzing data, and drawing conclusions.

The interactive E-Module can be accessed online via the following link: <https://heyzine.com/flip-book/dfc36d386f.html>. The display of the developed interactive E-Module is shown in Figure 1-3.



Figure 1. Front Cover of the Interactive E-Module

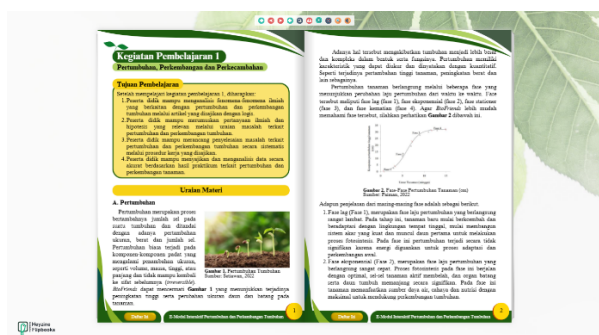


Figure 2. Content Page of the Interactive E-Module



Gambar 3. Back Cover of the Interactive E-Module

The interactive E-Module consists of three main sections: the introduction, the content, and the closing section. The introduction includes the front cover (as shown in Figure 1), a preface, table of contents, general information about the E-Module, its features, user guidelines, a concept map of plant growth and development, E-Module identity, Learning Outcomes (Capaian Pembelajaran/CP), and a brief description of the material. The content section contains the learning

objectives, explanations of the material (as shown in Figure 2), student activities, summaries, practice questions, and reflection activities. The final section includes a glossary, references, and the back cover (as shown in Figure 3).

The E-Module covers two main topics related to plant growth and development: (1) growth, development, and germination, and (2) factors that influence plant growth and development. Each topic is introduced with specific learning objectives. According to Hanida *et al.* (2023), learning objectives serve as important guidelines in the student learning process. Furthermore, the interactive E-Module contains various features designed to facilitate students in learning the material and developing scientific literacy skills. These features are categorized into main features and supporting features as described in Table 2.

Table 2. Interactive E-Module Features

Feature	Descriptions	Trained Indicators
 Go Search	Contains activities involving the observation of articles related to real-life phenomena.	Identifying scientific phenomena
 Go Wonder	Contains activities for formulating hypotheses and generating questions.	Formulating questions and hypotheses.
 Go Plan	Contains activities for designing experiments.	Designing solutions to problems.
 Go Found	Contains activities for data analysis and drawing conclusions based on experimental results.	Analyzing data, transforming data from one form to another, and drawing conclusions.

Table 2 presents the main features of the interactive E-Module include activities integrated with scientific literacy skill indicators, namely: (1) *Go Search*, which presents articles on real-life phenomena such as seed scarification and the addition of sugar water to plants; (2) *Go Wonder*, which involves formulating hypotheses and generating questions based on the given problem descriptions; (3) *Go Plan*, which contains student activities for designing experiments on differences in germination and plant growth; and (4) *Go Found*, which involves data analysis activities, data transformation into graphs, and drawing conclusions based on experimental

results. These features are available for both main topics in the E-Module: (1) plant growth, development, and germination, and (2) factors affecting plant growth and development. The main features were designed based on scientific literacy indicators and are implemented through learning activities in the E-Module (Faridah *et al.*, 2020).

The E-Module is also equipped with supporting features that facilitate the learning process and help students understand the content on plant growth and development. These include: (1) *Bio Discuss*, which serves as an interactive forum for student-teacher or peer discussions; (2) *Bio Recall*, which provides topic summaries; (3) *Bio Quiz*, which includes practice questions aligned with the material and provides feedback after completion; and (4) *Bio Reflect*, which offers students a space for reflection after completing the learning activities. These supporting features are presented as supplementary components to help deepen students' understanding of the learning content (Lastri, 2023).

One of the strengths of the developed interactive E-Module lies in its ability to support self-regulated learning—students' ability to manage their own learning processes through planning, monitoring, and evaluating their progress (Zimmerman, 2004). This is reflected in the module's structure and activities, which allow students to study independently and flexibly in terms of time, pace, and learning strategies. Features such as *Go Search*, *Go Wonder*, *Go Plan*, and *Go Found* facilitate students in actively understanding scientific phenomena, formulating hypotheses, and analyzing data without the need for intensive teacher guidance. In this model, the teacher acts more as a facilitator than a direct instructor (Kautsari *et al.*, 2022).

Another advantage of the interactive E-Module is the inclusion of the *Bio Discuss* feature, which creates a space for student discussions using Canva, and the *Bio Quiz* feature, which provides feedback after answering questions. This aligns with Wulandari (2022), who argues that interactive E-Modules are not just static teaching materials but offer multimodal experiences combining visual, auditory, and interactive elements engaging multiple senses in the learning process. Furthermore, Pramana *et al.* (2020) highlight that effective interactive E-Modules should be easy to navigate, capable of displaying various media formats, and include evaluation tools with automatic teacher feedback.

The validity of the interactive E-Module was evaluated by two validators: one specializing in instructional media and the other in subject matter content.

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The validation focused on three critical aspects: presentation (including visual design and layout), content accuracy and relevance, and the clarity and appropriateness of language used. This validation process was conducted to ensure that the E-Module meets academic and pedagogical standards, making it feasible and effective for use as a classroom learning resource by high school students (Andayani *et al.*, 2024). The assessment also served to identify potential improvements before classroom implementation. The results of the expert validation are presented in Table 3.

Table 3. Validity Results of Interactive E-Module (n=2)

No.	Components	Scor		Scor Aver age	Des	Aiken Index	Cat
		V 1	V 2				
A. Interface Aspect							
1.	Operational Quality	4	4	4	VV	1	H
2.	Cover Design Quality	4	4	4	VV	1	H
3.	Layout Quality	4	4	4	VV	1	H
4.	Image Quality	4	4	4	VV	1	H
5.	Video Quality	4	4	4	VV	1	H
6.	Interactivity Quality	4	4	4	VV	1	H
7.	Characteristics E-Modul	4	4	4	VV	1	H
8.	Preface	4	4	4	VV	1	H
9.	General Information	4	4	4	VV	1	H
10.	E-Module Features	4	4	4	VV	1	H
11.	User Guide	4	4	4	VV	1	H
12.	Glossary	4	4	4	VV	1	H
Average interface validity index							1
Interpretation							HV
B. Content Aspect							
13.	E-Module Componen	4	4	4	VV	1	H
14.	Material Quality	4	4	4	VV	1	H
15.	Practicum Quality	4	4	4	VV	1	H
Relevance to scientific literacy skill indicators							
16.	Explaining scientific phenomena	4	4	4	VV	1	H
17.	Evaluating and designing scientific investigations	4	4	4	VV	1	H
18.	Interpreting data and evidence scientifically	4	4	4	VV	1	H
Average content validity index							1
Interpretation							HV
C. Language Aspect							
19.	Language usage	4	4	4	VV	1	H

No.	Components	Scor		Scor Aver age	Des	Aiken Index	Cat
		V 1	V 2				
20.	Terminology usage	4	4	4	VV	1	H
Average language validity index							1
Interpretation							HV
Overall average validity index							1
Interpretation							HV

Keterangan:

V1: Validator 1 (Media Expert), V2: Validator 2 (Subject Matter Expert), VV: Very Valid, H: High, HV: High Validity, Des: Description, Cat: Category.

Based on Table 3, the aspects of presentation, content, and language each obtained an average score of 4.00, categorized as "very valid," with an Aiken's index of 1, indicating high validity. Therefore, the overall average validity score was 4.00 with a very valid category according to the Likert scale interpretation (Riduwan, 2016) and a high Aiken's index (Hsu *et al.*, 2015).

For the presentation aspect, an average score of 4.00 was obtained with an Aiken's index of 1, indicating high validity. The E-Module was deemed highly valid because it fulfilled several presentation quality components, including operational quality, cover design, images and videos, interactivity, alignment with E-Module characteristics, and supporting components such as the preface, general information, features, user guide, and glossary.

Operational quality received a score of 4.00 and an Aiken's index of 1, indicating that the interactive E-Module was easy to access and operate using a laptop or smartphone. It included clickable navigation menus and clear instructions. This supports Silaban *et al.* (2022), who stated that a well-operating E-Module enhances usability through intuitive navigation and instructions. Lastri (2023) also emphasized that effective operational quality improves students' understanding, learning motivation, and achievement of learning goals.

Visual presentation quality, including the cover, layout, images, and videos, also received scores of 4.00 and high validity. The cover was neatly designed with balanced layout, readable fonts, and harmonious color combinations. The images and videos had high resolution and reinforced the content. According to Kholifah *et al.* (2024), visual elements in an interactive E-Module are crucial in helping students grasp the material. Appropriate font selection also affects students' reading interest (Azizah & Rachmadiarti, 2023).

Interactivity quality also scored 4.00 with an Aiken's index of 1. Interactivity was assessed based on two-way interaction between students and the content or among

students themselves. This included navigational buttons, external links, discussion spaces, pop-up windows for independent activities, and automatic feedback for quizzes. Wulandari *et al.* (2021) noted that such interactivity increases student motivation through engaging and accessible content.

The E-Module's characteristics were also rated very valid, with a score of 4.00 and an Aiken's index of 1. According to Daryanto (2013), a good E-Module must exhibit five characteristics: self-instruction, self-contained, stand-alone, adaptive, and user-friendly. These were demonstrated in clear instructions, comprehensive content, independent functionality without external resources, modern platform use (Heyzine), and accessible language (e.g., "What do you think will happen? Let's find out"). One (2018) emphasized that such features enhance student comprehension.

For the content aspect, the module received a score of 4.00 and an Aiken's index of 1, categorized as highly valid. The content met four key criteria. First, the E-Module contained essential structural components such as learning objectives, evaluation activities, summaries, and references. Objectives aligned with Phase F Biology Learning Outcomes and integrated scientific literacy indicators, following Kemendikbud (2017).

Second, content relevance was also rated very valid. The module covered two major topics: growth and development stages, and influencing factors adapted to Grade XI characteristics. Rohmah *et al.* (2021) stressed the importance of well-structured content, while Klarisyah *et al.* (2019) highlighted the need for alignment with students' conceptual understanding. The materials were logically sequenced and avoided misconceptions, as also emphasized by Andaresta & Rachmadiarti (2021).

Third, the quality of practical activities received high validity. The module incorporated hands-on experiments directly related to the discussed topics, with clear instructions and realistic materials. Kusaeri (2014) argued that practical activities enhance understanding and engagement through empirical learning experiences.

Fourth, the learning activities were designed in alignment with scientific literacy skill indicators. These indicators are integrated into the features of the E-Module. The Go Search feature facilitates students in identifying scientific phenomena by analyzing articles related to seed scarification and the addition of sugar water to plants as a means to observe real-life scientific issues. The Go Wonder feature supports the formulation of hypotheses and scientific questions based on problems. descriptions presented in the module. Next, the Go Plan feature trains

students to design solutions to problems by requiring them to develop experiments to test the influence of specific variables on plant growth. The Go Found feature is used to analyze experimental results, convert data into graphs, and draw conclusions based on practical activities.

These indicators are based on PISA (2017), which include: identifying scientific phenomena, formulating hypotheses, developing scientific questions, designing problem solutions, transforming data from one form to another, analyzing data, and drawing conclusions. The learning activities are contextual to help students gain meaningful experiences, such as enhancing their scientific literacy skills (Rofiqoh & Faizah, 2019). This is in line with Akbar (2013), who stated that effective teaching materials should align students' competencies with the depth of content coverage.

The interactive E-Module was also developed with careful attention to language usage. The validation results for the language aspect showed an average score of 4.00 with a "very valid" category for both assessed components, each obtaining an Aiken's index of 1, indicating a high level of validity. For the language usage component, a score of 4.00 was obtained, categorized as very valid. This result indicates that the language used aligns with the *General Guidelines for Indonesian Spelling* (PUEBI), is unambiguous, clear, communicative, and informative. For the use of terminology, a score of 4.00 was also achieved, indicating that the biological terms used in the E-Module are appropriate, consistently applied, support the delivery of conceptual material, and do not lead to multiple interpretations.

Language assessment is essential, as emphasized by Graham & Misanchuk (2004), who stated that verbal elements, such as concise sentences, avoidance of complex vocabulary, and elimination of excessive information, are crucial to ensure that students fully understand the reading content. Likewise, Sihafudin and Trimulyono (2020) emphasized that appropriate language and terminology usage in instructional materials is vital for helping students grasp meanings easily and avoid misinterpretations.

The overall validity assessment based on the presentation, content, and language aspects resulted in an average score of 4.00 with a "very valid" category and an Aiken's index of 1, indicating high validity. These results are in accordance with the standards from the *National Education Standards Agency* (BNSP, 2017), which state that teaching materials are considered to meet development standards if they fulfill content feasibility,

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presentation, language, and graphical quality. Thus, the validity results confirm that the developed interactive E-Module is valid and ready for implementation in student learning.

CLOSING

Conclusion

The study produced a teaching material in the form of an interactive E-Module on plant growth and development that is feasible for training students' scientific literacy skills. The E-Module is equipped with features such as Go Search, Go Wonder, Go Plan, and Go Found. It meets the eligibility criteria based on validity in terms of presentation, content, and language, with a very valid category and a high level of expert agreement.

Suggestion

The researcher recommends conducting further similar studies involving the development of interactive e-modules using more advanced or premium-level websites, which would allow tracking of students' activity history through stored data. In addition, future research is needed to explore the use of interactive e-modules in supporting other 21st-century education skills beyond scientific literacy, such as digital literacy, critical thinking, collaborative work, and other essential competencies.

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