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The Development of Flower Morphology' E-Module Using Local Potential from Tahura R. Soerjo as a Learning Resource to Train Student' Botanical Literacy

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ABSTRACT
Nowadays, it is important to impower botanical literacy to eliminate igorance towards plants. Furthermore, botanical literacy exists to understand why plants are relevant to daily life and emphasizes their role in sustaining life. Based on the results of a needs analysis observation, teaching materials that explicitly contain botanical literacy indicators are still limited. Through a flower morphology e-module that incorporates the local potential of Tahura R. Soerjo, students' botanical literacy can be effectively trained. This research used the Lee & Owens (2004) research and development design, include assessment/analysis, design, development, implementation, and evaluation. The population for this study were sophomore Biology students who were enrolled in the Plant Generative Structure and Development course for the 2024/2025, from which two classes were then determined as research samples. The instruments used in the study were questions, questionnaires, and observation sheets adapted to the aspects of botanical literacy. The ANCOVA test results showed that the e-module had a significant influence on students' botanical literacy with a (Sig.) of 0.001 > 0.05. The e-module is effective for training students' botanical literacy.

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1. INTRODUCTION

Plants play a crucial role in life. Besides constantly releasing oxygen, plants provide habitat for many species and regulate the Earth's climate (Boyce & Lee, 2017). The needs of humans and all other organisms are met by consuming and utilizing plants daily. The reality on the ground shows that many people still ignore the importance of plants to the environment. This indifference towards plants is a factor that contradicts environmental balance and directly hinders the achievement of most Sustainable Development Goals (Amprazis & Papadopoulou, 2020). Furthermore, Batke *et al*. (2020) stated that neglecting plants can increase the loss of global biodiversity and allow for a relational gap between humans and plants, meaning the disregard for plants cannot be avoided.

Indifference towards plants contributes to a lack of interest in studying them. This neglect is caused by several interconnected factors. According to Wandersee (1986), the tendency to disregard plants stems from humans' greater preference for animals and a lack of positive attitudes towards plants. Furthermore, Hoekstra (2000) stated that animals are considered more engaging due to their activity, movement, vocal communication, diverse behaviors, and physical resemblance to humans. In contrast, plants are considered more difficult to understand and detect, leading to greater attention being given to animals (Batke *et al*., 2020). Another factor contributing to the neglect of plants is plant blindness. Plant blindness is a tendency for individuals to overlook or undervalue plants, rendering them unable to recognize the importance of plants in ecosystems and human life (Balas & Momsen, 2014; Wandersee, 1986).

This indifference towards plants must be brought to an end. Concern over this neglect gave rise to the term botanical literacy, which was pioneered by Uno (1994) based on earlier work on biological literacy as part of the science curriculum for university students (Uno & Bybee, 1994). Botanical literacy uses knowledge of plants to understand why plants are relevant to daily life. Students who possess good botanical literacy can reduce their disregard for plants and the plant blindness phenomenon, and increase their awareness of the importance of plants in human life (Colon *et al*., 2020).

A needs analysis regarding botanical literacy conducted on Biology students from the 2022 cohort, who had completed the Plant Generative Structure and Development course, showed a score of 53.73, categorized as poor. The lowest score students achieved was in explaining plant structure and function, followed by differentiating plant habitus, while the highest score was in writing scientific plant names. Observations by Sari *et al*. (2021) indicated that students experienced significant difficulties in understanding basic botany, which resulted in their botanical literacy being classified as poor. Consistent with direct and indirect interviews conducted with one of the course lecturers, the low botanical literacy of these students is attributed to learning that has not been conducted in detail and has not utilized existing indicators. This is due to the limited teaching materials that explicitly contain botanical literacy indicators.

Increasing botanical literacy is important to reduce indifference towards plants and the plant blindness phenomenon. Hence, steps should be taken to enhance botanical literacy in botany courses that students will undertake. Steps like developing teaching materials and adding references in botany lectures, as existing teaching materials and references for botany lectures are still limited and need to be developed. This is in accordance with the results of the analysis of student needs, 60% of students need the development of teaching materials based on local potential. One form of teaching material that can be used is an electronic module. Electronic module have so many advantages such as the ability to display text, images, animations, and videos (Laili, 2019). The use of e-modules is not limited by place and time because they utilize electronic devices for access (Hutahaean, 2019). The material in e-modules can broaden students' insights and knowledge, and features like glossaries and indexes enable students to understand the definitions of difficult terms (Anggraeni *et al*., 2021).

According to Uno (2009), one of the keys to reducing "plant blindness" and increasing botanical literacy is by using inquiry-based activities. Therefore, the appropriate learning model to use in e-module development is guided inquiry. In addition, the selection of the guided inquiry learning model was also informed by the findings of Şen & Vekli (2016), who reported its suitability for developing botanical literacy. Uno (2009) stated that studying content in teaching materials while engaging in inquiry-based activities is an effective way for students to understand content and develop thinking skills. Inquiry-based activities implemented by teachers must have a philosophical mindset based on constructivist principles. The implication of constructivism in the science classroom is that students actively construct and reconstruct knowledge through direct interaction, leading to a deeper understanding of how they learn. These constructivist principles are consistent with inquiry practices, so it is important for teachers to have a strong foundation in constructivist propositions (Llewellyn, 2013:65).

E-module was developed by utilizing local potential as a learning resource. Given its vast local potential, Indonesia boasts many local natural resources that can be effectively utilized as learning sources (Anggraeni *et al*., 2021). One such local potential that can serve as a learning resource is Taman Hutan Raya Raden Soerjo. Specifically, the chosen sub-region is Loka Wisata Surya, located in Pacet, Mojokerto, East Java. This location is an educational tourist area for introducing mountain forest ecosystems as well as flora and fauna. Many flora and fauna can be found in this area, both documented and undocumented (UPT Tahura R. Soerjo, 2022). Research by Anggraeni *et al*. (2021) demonstrated that developing teaching materials integrating local potential, like the Cibodas Botanical Garden, can enhance students' botanical literacy. Other research also explained that teaching materials can be used as a guide for students to study plants (Muhfahroyin & Oka, 2021). Based on this, the researchers developed a flower morphology e-module utilizing Tahura R. Soerjo as a learning resource. This e-module aims to be valid, practical, and effective in training students' botanical literacy.

2. RESEARCH METHOD

This study was a research and development based on the Lee & Owens model. The stages in this research model include assessment and analysis, design, development, implementation, and evaluation (Lee & Owens, 2004). Assessment and analysis were conducted to obtain information regarding existing gaps, their causes, and potential solutions. Design is the planning phase for the product that will be developed. Development and implementation include pre-production, production, and post-production activities. During this stage, the product will be created and implemented. The evaluation aimed to determine the developed product's quality and its feasibility for learning. The population for this study were sophomore Biology students who were enrolled in the Plant Generative Structure and Development course for the 2024/2025. The sample selected using a random sampling technique, consisted of 33 students in the control group and 29 students in the experimental group. The research instruments used to collect data were questionnaire sheets, observation sheets, and botanical literacy test sheets, all of which had been validated by validators. Botanical literacy comprises conceptual and procedural knowledge domains, modified from Pongsophon & Jituafua (2021). The implementation of the e-module used a Nonrandomized Control-Group Pretest-Posttest Design quasi-experimental design (Table 1). Implementation was conducted across four meetings, with the guided inquiry learning model syntax repeated twice for distinct sub-materials.

Table 1. Quasi-experimental Design

Groups	***Pretest***	**Treatment**	***Posttest***
Experimental	Obs 1	X_1	Obs 3
Control	Obs 2	X_2	Obs 4

Source: Leedy & Ormrod (2021)

Botanical literacy analysis was conducted using one-way ANCOVA with a significance level of 5%, using students' pretest and posttest scores. Before the data were analyzed by one-way ANCOVA, prerequisite tests were conducted. Normality test used Kolmogorov-Smirnov test, while homogeneity test used Levene's Test of Equality of Error Variance.

3. RESULT AND DISCUSSION

The e-module used has undergone several stages, including assessment and analysis, design, development, implementation, and evaluation.

Assessment and Analysis

The assessment and analysis consisted of two parts: needs assessment and front-end analysis. The needs assessment was conducted with Biology students who had completed the Plant Generative Structure and Development course, as well as the course lecturers. Based on distributed questionnaires, the needs analysis indicated that students' botanical literacy scores were low. Students need to possess good botanical literacy to overcome the plant blindness phenomenon. This phenomenon can cause students to overlook the importance of plants in human life. Through direct and indirect interviews, a needs analysis with course lecturers revealed that limited references and teaching materials contribute to low botanical literacy.

The front-end analysis was conducted to obtain more detailed information about what would be developed. Several types of front-end analysis were performed. First, an audience analysis was conducted to identify the subjects' background, learning characteristics, and prerequisite skills. The subjects in this research were sophomore Biology students enrolled in the Plant Generative Structure and Development course, and they naturally came from diverse regions. Their native languages were Bahasa Indonesia and Javanese. No students required special treatment in lectures. Students found flower morphology to be the most difficult material, frequently causing misconceptions. Its many foreign terms necessitate careful study to improve students' botanical knowledge.

Second, the technology analysis was conducted to identify currently used technologies and determine which ones students were familiar and comfortable with. The analysis revealed that most students primarily used mobile phones for learning, with laptops being used occasionally. Third, the situational analysis was performed to identify constraints that might impact the goals and design of the teaching materials. Fourth, the task analysis was conducted to break down the work into simpler parts and identify the necessary knowledge, skills, and attitudes for the researchers. This analysis outlined the responsibilities of the development team, which included researchers/developers, supervisors, media experts, content experts, and field practitioners. Fifth, the critical incident analysis was conducted to determine what skills or knowledge were targeted in this research. The target of this research was to train botanical literacy in flower morphology material.

Sixth, the objective analysis was performed to determine solutions and objectives for the existing problems. This research aimed to develop a valid, practical, and effective local potential-based e-module for training botanical literacy. Seventh, the media analysis determined the most appropriate delivery medium, which was a flipbook product created with software, easily accessible via smartphones and laptops. Eighth, the extant data analysis was conducted to identify existing materials, references, and syllabi, specifically Rencana Perkuliahan Semester (RPS). This analysis also revealed that while course lecturers provided PPTs and practical guides, these existing teaching materials and media for lectures were not yet neatly or comprehensively organized. Finally, the cost analysis was performed to determine the total expenses incurred throughout the product development process, from its initial to final stages.

Design

The design phase consisted of project schedule planning, project team formation, media/product specifications, content structure, and configuration control. The development schedule included: 1) assessment/analysis in June 2024; 2) design in July-August 2024; 3) development in August-September 2024; and 4) implementation and evaluation in October-December 2024. The project team consisted of the researcher as the product developer, a supervising lecturer, a team of validators, and education practitioners.

Media/product specifications guided the design and standards of the developed media. The project specifically focused on creating a flower morphology e-module that used Tahura R. Soerjo as a learning resource, aiming for validity, practicality, and effectiveness. Key media specifications included theme, writing style and grammar, text and graphic design standards, images, and video. The final product was developed in A4 PDF format and then converted into a flipbook using Heyzine.

The developed e-module's content structure was organized into smaller units, including concepts, processes, procedures, principles, and facts. The flower morphology material presented within the e-module directly referred to the previously developed CPMK and sub-CPMK. The arrangement of this content began with an understanding of the RPS (Rencana Perkuliahan Semester), followed by a search for credible references. Additionally, local potential, such as the flower morphology of Tahura R. Soerjo, was integrated as a supplementary learning resource. Configuration control was crucial for managing the workflow. This ensured the developed product could be completed on time, maintain good quality, and adhere to all expected specifications.

Development and Implementation

The development phase was structured into three key activities: pre-production, production, and post-production, including quality review.

Pre-production began after the content was prepared. The next crucial step was to create a storyboard, which served as a guiding blueprint for subsequent product development. This storyboard adhered to the technical and instructional standards established during the design phase. During production, the collected content was assembled according to the storyboard. The e-module was developed using tools such as Canva, Google Drive, and Google Form. The final e-module specifically contained flower morphology material (Figure 1). Following production, the e-module entered the quality review stage. This involved validation by material experts, media/teaching material experts, and education practitioners. Revisions to the e-module were then made based on the comments and suggestions received from the material expert validator. The validation results from the material expert showed an average percentage of 100%, categorizing the e-module as "very valid" (Table 2). The e-module achieved this "very valid" status because its content was found to be both correct and relevant. As Magdalena et al. (2020) note, material presentation should be arranged sequentially and consistently to facilitate student understanding of concepts.

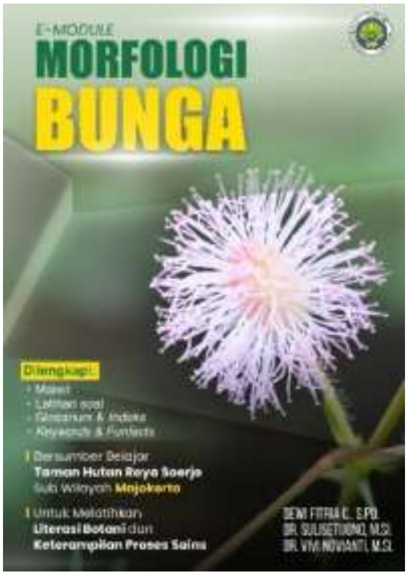

Figure 1. E-Module Display

Table 2. Material Expert Validation Results

No.	Aspects	Percentage (%)	Category
1.	Curriculum aspect	100	Very valid
2.	Introduction	100	Very valid
3.	Flower evolution: competency aspects	100	Very valid
4.	Flower morphological structure: competency aspects	100	Very valid
5.	Flower evolution: presentation feasibility	100	Very valid
6.	Flower morphological structure: presentation feasibility	100	Very valid
7.	Flower evolution: language feasibility	100	Very valid
8.	Flower morphological structure: language feasibility	100	Very valid
	Average	**100**	**Very valid**

The developed e-module also underwent review for its media and teaching material characteristics. The media/teaching material validity test yielded an average percentage of 92,14%, classifying it as "very practical" (Table 3). To achieve good visualization, the e-module's design considered color harmony, writing layout, font type and variation, and illustration compatibility. Asri & Dwiningsih (2022) note that e-modules incorporating appropriate visual elements, such as icons and illustrations, and emphasizing key points, can make the material more lively and engaging to read.

Table 3. Media and Teaching Material Experts Validation Results

No.	Aspects	Percentage (%)	Category
1.	E-module size	100	Very valid
2.	E-module cover	94	Very valid
3.	E-module graphics	90	Very valid
4.	Self instructional	93	Very valid
5.	Self contained	80	Valid
6.	Stand alone	80	Valid
7.	Adaptive	100	Very valid
8.	User friendly	100	Very valid
	Average	**92.12**	**Very valid**

The developed e-module also validated by Biology education practitioners. This validity test resulted in an average percentage of 86,94%, placing it in the "very valid" category (Table 4). The validated e-module successfully met the technical aspects of presentation, meaning it was logically structured with an introduction, content, and conclusion. Furthermore, the e-module presented concepts in a progressive manner, moving from easy to difficult and from simple to complex. As Muldiyana et al. (2018) suggest, packaging concepts into such specific units makes it easier for students to learn the material.

Table 4. Biology Education Practitioners Validation Results

No.	Aspects	Percentage (%)	Category
1.	Presentation technique	87	Very valid
2.	Material presentation support	85	Very valid
3.	Learning presentation	90	Very valid
4.	Completeness of Presentation	87	Very valid
5.	Language usage	85,7	Very valid
	Average	**86,94**	**Very valid**

The formative evaluation was conducted in three stages after the product was deemed valid: one-to-one trials, small group trials, and field trials. The results from these trials were consistently high, with percentages of 85,33%, 88,32%, and 85,34% respectively. All three stages were consequently categorized as "very practical" (Table 5).

Table 5. Product Trial Results

No.	Product Trial	Number of Subjects	Percentage (%)	Category
1.	One-to-one trial	3	85,33	Very practical
2.	Small group trial	10	88,32	Very practical
3.	Field trial	34	85,34	Very practical
	Average		**86,33**	**Very practical**

Implementation

Once the product was declared practical, implementation and effectiveness testing were conducted to assess its impact on botanical literacy. Sample determination followed an assessment confirming the population was normal, homogeneous, and equivalent. For this research, two classes were involved: one as the control group and the other as the experimental group. Random sampling was used to select the samples, resulting in Offering G 2023 becoming the control group and Offering A 2023 the experimental group. After obtaining the pretest and posttest scores, a descriptive analysis was performed to observe score increases in both classes. The control class showed an increase of 63,1%, while the experimental class experienced a slightly higher increase of 71,3% (Table 6).

Table 6. Botanical Literacy Score Improvement in Control and Experimental Classes

No.	Groups	Botanical Literacy				Description
		Pretest	*Posttest*	Difference	Improvement (%)	
1.	Control	40,2	65,6	25,4	63,1	Increased
2.	Experimental	42,6	73	30,4	71,3	Increased

Evaluation

Knowledge evaluation was conducted to determine the effectiveness of the e-module implemented in the control and experimental classes. The data was analysed with ANCOVA test. Prerequisite tests were conducted before performing the hypothesis test using pretest and posttest scores in each class. These included both normality and homogeneity tests. The normality test results showed that the data were normally distributed, as the significance (Sig.) value was greater than 0.05 (Table 7). Similarly, the homogeneity test confirmed that the data were homogeneous, also indicated by a significance (Sig.) value greater than 0.05 (Table 8).

Table 7. Botanical Literacy Normality Test Result

Groups	N	*Pretest*		*Posttest*	
		Sig.	Decision	Sig.	Decision
Control	29	0,244	Normal	0,123	Normal
Experimental	33	0,260	Normal	0,259	Normal

Table 8. Botanical Literacy Homogeneity Test Result

Test	Sig.	Decision
Pretest	0,176	Homogen
Posttest	0,495	Homogen

The effectiveness test, conducted using an ANCOVA analysis, yielded a significance (Sig.) value of 0.001, which is less than 0.05. This indicates a significant difference between the treatments applied to the control and experimental classes. Specifically, the average corrected posttest score for botanical literacy in the control class was 66,3, while the experimental class achieved 72,5. The differing letters above these numbers further confirm this significant difference (Table 9). Based on these findings, it can be concluded that the e-module significantly impacted students' botanical literacy.

Table 9. Average Corrected Botanical Literacy Posttest Scores

Groups	Average
Control	$66{,}3 \pm 9{,}42^{a}$
Experimental	$72{,}5 \pm 9{,}16^{b}$

Note: Numerical values marked with the same letter are not significantly different.

A key strategy for reducing plant blindness and boosting botanical literacy involves incorporating inquiry-based activities. These activities actively engage students in seeking and discovering answers to questions or problems (Damopolii *et al*., 2019). Specifically, these inquiry-based activities are implemented using the guided inquiry learning model. This model has proven effective in developing botanical literacy because it encourages students to utilize as many senses as possible. One practical way this occurs is through direct engagement with practicum materials, such as flowers.

Direct student involvement with plants, particularly through observing and interacting with floral organs, significantly fosters interest in flora. This process engages affective, cognitive, and psychomotor aspects, prompting students to pay closer attention to the detailed morphology of flowers and their environmental role. Students begin to perceive plants not as passive organisms, but as vital living components of the ecosystem (Pagare et al., 2015). Activities centered on floral organs as reproductive structures instill a fundamental understanding of plant sustainability's importance. This heightened awareness directly correlates with a reduction in careless or destructive behavior toward plants, as students start to appreciate the ecological functions they perform. This finding is consistent with the results of the attitude questionnaire filled out by students, which highlighted plants as a dominant factor in preventing environmental damage.

The introduction of local potential of Tahura Raden Soerjo's Mojokerto Sub-Region through the e-module significantly boosted students' interest in plants, especially those rarely encountered or previously unknown. For instance, students who once struggled to identify local flower species can now do so with high enthusiasm, delving into the morphology details, uniqueness, and interesting facts of flowers. This demonstrates a notable shift in students' perception of and interaction with the plant diversity in their environment. A prime example is their dissection of a papaya flower, where students discovered the fascinating fact that a single papaya tree can bear only male, only female, or even hermaphroditic flowers. As Niazi et al. (2023) highlight, this direct interaction between students and plants not only familiarized them with plant existence but also enabled them to understand unique characteristics and their crucial role in the environment.

Botanical literacy, encompassing cognitive, affective, and psychomotor outcomes, provides a truly comprehensive understanding of plants. This holistic approach enriches students' grasp of plant concepts while fostering positive attitudes and practical skills. Ultimately, this supports environmental sustainability both in education and daily life. Furthermore, botanical literacy can significantly increase awareness of crucial environmental responsibility, especially in the era of climate change. This expanded concept of botanical literacy will be more relevant and helpful in addressing current environmental and social challenges, actively building a generation aware of maintaining ecosystem balance (Arif et al., 2025).

4. CONCLUSION

The flower morphology e-module can be used in learning. Following a series of rigorous tests, it has been declared valid, practical, and effective to train students' botanical literacy in learning the material of Plant Generative Structure and Development. Its relevance in learning stems from the use of a guided inquiry model, which presents students with concrete phenomena to explore, enabling them to discover concepts independently. E-module based on local potential to train botanical literacy can be developed in other materials.

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