

Development for E-Module for Plant Physiology Courses to Increase Student's Critical Thinking Skills

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ABSTRACT

This media development aims to develop, validate, practicality and effectiveness of e-modules designed to enhance critical thinking skills in Plant Physiology Course. The e-module focused on plant translocation, cell respiration, and development and growth factors. The research follows R&D using the Lee & Owens model, which includes five stages (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation. The study involved 33 third-semester biology education students at the State University of Malang. Result from the validation process show that the media achieved a 95% validation rate, categorized as "Very Valid", while the material validation scored 100% also "Very Valid", practitioner validation scored 93.9% falling into the "Very Valid". The practicality test obtained a score of 88.6% indicating "Very Practical". The effectiveness test obtained based on pretest and posttest scores from experimental and control groups, resulted in an N-gain score of 0.53 included in the "Moderate". Based on the test results that the e-modules for plant physiology courses to increase student's critical thinking skills is said are valid, practical, and effective.

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1. INTRODUCTION

Transformation of education at this time is a very appropriate choice in developing science and technology. The 21st century is currently an era that emphasises the era of information and technology (Fahrozy et al., 2022). Lecturers must also be able to develop teaching materials that utilise current technology and information such as e-modules that can be used. E-Module is an electronic module or book in soft file form that can be opened and studied anywhere and anytime by students (Yetti & Ahyuardi, 2020). Teaching materials developed in the form of e-modules are expected to make students think critically and collaborate in lectures (Utami & Yuwaningsih, 2020). Efforts to foster these critical thinking skills, educators need to create an active learning atmosphere supported by appropriate learning media (Sa'adah et al., 2020).

Current learning emphasises students' meaningful critical thinking, enabling students to solve problems with more meaningful learning. Students are trained to think critically through thinking skills that not only require memory skills but also require other higher skills (Murdiana et al., 2020). Critical thinking is a high-level thinking skill that has the potential to increase student's critical analytical power (Susilawati et al., 2020). Critical thinking is purposeful, reasoned, and goal-directed thinking. This type of thinking as in problem solving, inferring, and making decisions when at the time of thinking using skills that are thoughtful and effective in a particular context (D'Alessio et al., 2019).

The results of the needs analysis obtained through questionnaire distributed to students of the Department of Biology at the State University of Malang on 2 April 2023. Teachers have used electronic-based teaching materials and media such as the use of electronic modules or called e-modules. During lectures, the method often used is presentation discussions with the use of learning models such as Problem Based Learning (PBL), Project Based Learning (PjBL), and many more. Lecturers have implemented critical thinking skills, argumentation, scientific reasoning, communication, collaboration, and problem solving. However, critical thinking skills remain low in the learning processes. Students demonstrate low proficiency in using data. Therefore, students required electronic-based teaching material to enhance 21st Century skills, especially critical thinking. Consequently, this research developed a critical thinking e-module for the Plant Physiology course.

2. RESEARCH METHOD

The type of research used in the study is Research and Development (R&D) research. One of the development models that can be used in development research is the Lee & Owens model. The following are the stages of the Lee & Owens development model in Figure 1.

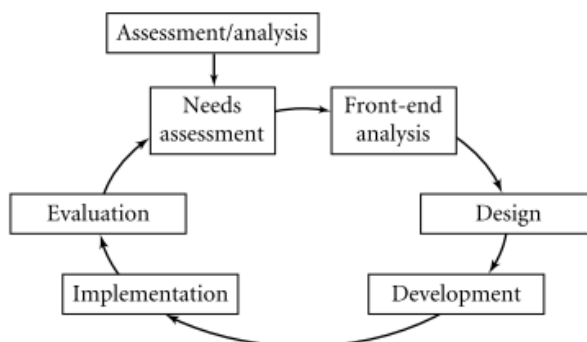


Figure 1 Stages of the Lee & Owens Model

Source: Lee & Owens, (2004:3)

Data collection techniques consisted of questionnaires, tests, and documentation. The data analysed were validity, practicality, and effectiveness. This research design uses the Nonrandomised Control-Group Pretest-Posttest Design research type and uses the Normalised Gain (N-Gain) calculation. The research implementation design with Nonrandomised Control-Group pretest-posttest Design can be seen in Table 1.

Table 1. Nonrandomised Control-Group pretest-posttest Research Design

Group	Pretest	Treatment	Posttest
Experimental	O ₁	X ₁	O ₂
Control	O ₃	X ₂	O ₄

Source: Leddy dan Ormrod, (2021:233)

a. Validity of E-Module

The validation uses a Likert Scale with the author's modification, the following formula is used to calculate the validation results.

$$V\text{-ah} = \frac{TSe}{TSh} \times 100\%$$

Sumber: Akbar, (2017:82)

The results obtained with the criteria presented in Table 2.

Table 2. Guidelines for the Validity of Data Analysis in Percentages

Achievement Level (%)	Qualification	Description
81-100	Very Valid	E-module is used without revision
61-80	Valid	E-module is used with little revision
41-60	Less Valid	E-module is not recommended as it needs major revisions
20-40	Invalid	E-module cannot be used
0-20	Very Invalid	E-module cannot be used

Sources: Akbar, (2017:82)

b. Practicality of E-module

E-module is considered practical when users do not encounter difficulties during development and use. Indicators of e-module practicality can be seen from the responses of students who can operate easily (Akbar, 2017: 82). The following formula is used in calculating practicality.

$$V\text{-pg} = \frac{TSe}{TSh} \times 100\%$$

Sources: Akbar, (2017:82)

Description:

V-pg: user validation

Tse: validator's total empirical score

TSh: maximum expected score

The results obtained with the criteria presented in table 3.

Table 3. Guidelines for the Validity of Data Analysis in Percentages

Level of achievement (%)	Qualification	Description
81-100	Very practical	E-module is used without revision
61-80	Practical	E-module is used with little revision
41-60	Less practical	E-module is not recommended as it needs major revisions
20-40	Not practical	E-module cannot be used
0-20	Very not practical	E-module cannot be used

Sources: Akbar, (2017:82)

c. Effectiveness of E-module

The N-gain score test is a test that can provide a general description of the increase in pre-test and post-test results. Gain Normality Test is a test that can provide an overview of the increase in learning outcome scores between before and after the application of a treatment. The effectiveness of e-module can be calculated with the N-Gain test formula as follows.

$$\text{Normalized Gain (g)} = \frac{\text{posttest score} - \text{pretst score}}{\text{maximum score} - \text{pretest score}}$$

The following is a description of the effectiveness assessment in Table 4.

Table 4. N-Gain Level Categories

Category	Limits
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Medium
$g \leq 0,3$	Low

Sources: Hake, R, (1999:1)

3. RESULT AND DISCUSSION

A. RESULT

E-Module Development Process

The process of developing this interactive media product refers to previous research, namely from (Sagita et al., 2021) developing an e-module aims to improve students' critical thinking. Research and development produce e-modules on the material of Photo assimilate Translocation, Cell Respiration, and Development and Growth Factors in the Plant Physiology course. This e-module has been validated by validators.

1) Analysis

Needs analysis was taken through distributing questionnaires to students majoring in biology on 13 February 2023 at the State University of Malang. The activity obtained the results that the learning models expected by students such as Problem Based Learning (PBL), Project Based Learning (PJBL), Tim Games Tournament (TGT), and Discovery Learning. The obstacles experienced by students in learning plant physiology courses in class learning are methods with a percentage of 29.6% and media with a percentage of 22.2% which is the most percentage of obstacles. Students are constrained by methods that are less able to increase student motivation, teaching materials and media provided can be added.

2) Design

This stage of media products focuses on the results of the needs analysis which is used as a basis for developing the developed e-module. The implementation of the development was designed starting in June 2023 until October 2023. The following are the design results of the E-module that has been developed, presented in the picture below.

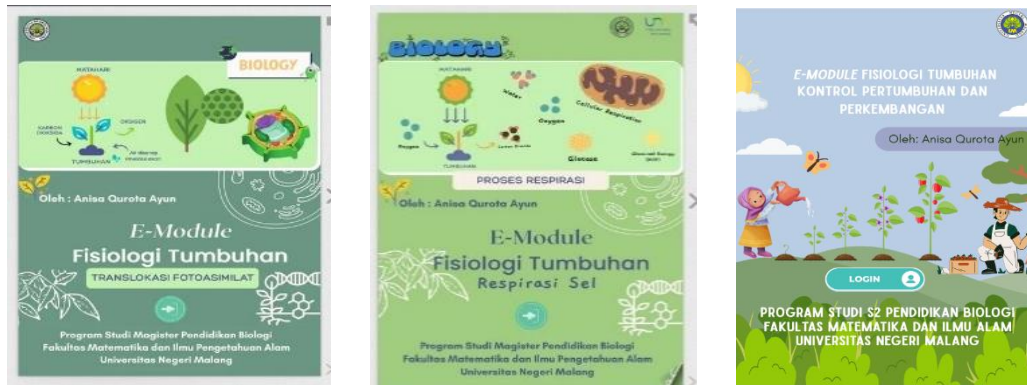


Figure 4.1 Cover E-module

The cover displays of the material for Translocation (right), Respiration (center), and Growth and Development (left) in the e-module.



Figure 4.2 Home Menu

The home screen display of the e-module consists of a guide menu, concept map, and several other menus.



Figure 2.3 Material Menu

The material menu display of the e-module, featuring Translocation (right), Respiration (center), and Growth and Development (left), with back, home, and next buttons.



Figure 4.4 LKM Menu

The display of the available menu in LKM within the e-module, integrated with the PBL learning model for LKM activities.



Gambar 4.5 Evaluation Menu

The display of the evaluation menu for Translocation (right), Respiration (center), and Growth and Development (left) materials in the module

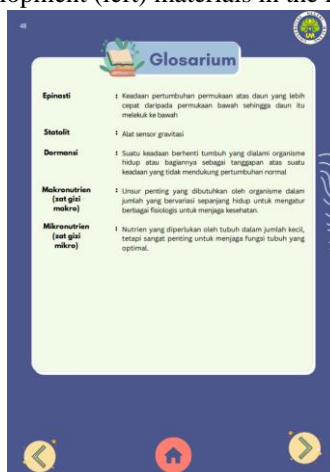


Figure 4.6 Glossary Menu

3) Development

The media developed in this study is an e-module that is operated on laptops and computers on the material of translocation of photoassimilates, cell respiration and control of growth and development. E-modules are given

to validators to determine the validity of the media that has been developed. The validation process to the validator provides a validation assessment questionnaire sheet. Then the media is revised according to the input or suggestions given by the validator. After being declared valid and feasible in the trial, the media is ready to be implemented.

4) Implementation

E-modules that have been declared valid and feasible are tested on 3rd semester students in 2 classes of biology education department at State University of Malang. Field trial activities were carried out on 14 September 2023 until 2 November 2023, implementation twice a week.

5) Evaluation

This stage is collecting data on the results of validation and field trials. Validation of materials, media, and biological education practitioners. The results of the data are evaluated for consideration in determining validity and can be used in trials on semester 3 students totalling 33 students from 2 classes majoring in biology education from the e-module that has been developed.

Data presentation

Presentation of data describes the results of validation and field trials. The following is the presentation of the data as follows:

1) Validation

The following are the results of data analysis of validation of e-modules, namely media validation, material validation, and validation of biology education practitioners.

a) Media Validation

Media validation was conducted to a media expert lecturer, Prof. Dr. Dedi Kuswandi, M.Pd on 1 October 2023. This validation is done to provide an assessment of the e-module.

Table 6. Results of validation assessment of E-module

No.	Aspects Assessed	Score
Cover Design of E-Module		
1.	The appearance of the layout elements on the cover harmoniously has a consistent rhythm and unity	5
2.	The colours of the layout elements are harmonious and clarify functions	5
3.	The font used is attractive and easy to read	5
4.	Does not use too many letter combinations	5
5.	The cover illustration describes the content of the material and the character of the object	4
6.	The cover illustration has a colour, size, and proportional shape	5
E-module Content Design		
7.	Placement of layout elements is consistent based on the pattern	5
8.	Separation between paragraphs is clear	5
9.	Proportional print and magazine fields	5
10.	Spacing between text and illustrations is appropriate	4
11.	Completeness, illustrations and picture captions	5
12.	Placement of decoration/illustration as background does not interfere with title, text, and page numbers	4
13.	Placement of titles, subtitles, illustrations and captions, does not interfere with understanding	5
14.	The use of letter variations (bold, italic, underline) is not excessive	4
15.	The width of the text is normal	5
16.	Spacing between lines and text arrangement is normal	5
17.	The level of subtitles is clear, consistent and proportional	4
18.	Illustrations are able to reveal the meaning/meaning of the object	5
19.	Content illustrations have accurate and proportional shapes	5
20.	Creative and dynamic	5
The percentage		95%

The score calculation above shows that the results obtained by product validation are a percentage value of 95%. The results of android-based interactive media validation are in accordance with the criteria "Very Valid" or can be tested without revision. Comments and Suggestions on *e-module* media, namely that it can be tested.

b) Material validation

Material validation is given to the validator lecturer. The validator of PBL material and SAP is Dr. Husanah, M.Pd. on September 11, 2023. The following are the results of the material validation that has been carried out.

Table 7. Result of the First Material Validation Assessment

No.	Aspects Assessed	Score
Title		
1.	Topic title is in accordance with learning outcomes and indicators	5
2.	The topic title can describe the content of the material	5
Example or Illustration		
3.	In accordance with the content of the material	5
4.	Facilitate students in understanding the material	5
5.	Source of examples or illustrations from reliable sources (journal/textbook)	5
Picture/photo/video		
13.	Images/photos/videos are presented clearly (size)	4
14.	Images/photos/videos make it easier for students to understand the material	4
15.	Images/photos/videos in accordance with the topic of the material discussed	5
Language		
16.	The language is clear and easy to understand	5
17.	Writing scientific language in accordance with the systematics of writing scientific names	4
18.	Writing scientific language in accordance with the systematics of writing scientific names	5
Depth/extent of material		
19.	The material explains the concepts that must be mastered by students	5
20.	The material makes it easy to master concepts	5
Correctness of Material Concepts		
21.	The material presented contains the correct concepts	5
22.	Creative and dynamic	5
The percentage		72%

The results of the validation test to obtain an assessment and comments and suggestions as a consideration in making material improvements. There are suggestions and recommendations for improvement purposes, namely the need for revision of the linguistic aspects, it would be very good to improve the quality if it is considered a revision with the statement that the e-module is valid and can be field tested with minor revisions. The following results of the second material expert validation can be seen in Table 8.

Table 8. Second Material Validation Assessment Result

No.	Aspects assessed	Score
Title		
1.	Topic title is in accordance with learning outcomes and indicators	5
2.	The topic title can describe the content of the material	5
Example and Illustrations		
3.	In accordance with the content of the material	5
4.	Facilitate students in understanding the material	5
5.	Source of examples or illustrations from reliable sources (journal/textbook)	5
Picture/photo/video		
13.	Images/photos/videos are presented clearly (size)	5
14.	Images/photos/videos make it easier for students to understand the material	5
15.	Images/photos/videos in accordance with the topic of the material discussed	5
Language		
16.	Language is clear and easy to understand	5
17.	Writing scientific language in accordance with the systematics of writing scientific names	5
18.	Consistency in the use of words or terms	5
Depth/extent of material		
19.	The material explains the concepts that must be mastered by students	5
20.	The material makes it easy to master concepts	5
Correctness of Material Concepts		
21.	The material presented contains the correct concepts	5
22.	Creative and dynamic	5
The percentage		100%

The validation results are in accordance with the "Very Valid" criteria or can be tested. Comments and suggestions given by the validator, namely revisions / improvements, are in accordance with the suggestions and are suitable for use.

c) Validation of biology education practitioners

Material validation was given to a validator lecturer. The Biology Education Practitioner validator is Dr. Husamah, S.Pd., M.Pd. on September 11, 2023. The following are the results of the practitioner validation that has been carried out.

Table 9: Biology Education Practitioner Validation Results

No.	Assessment Aspect	Score
Completeness of contents		
1.	The media is consistent with the learning objectives	5
2.	Media has the benefit of broadening students' horizons	5
3.	Media comes with a preface, table of contents and bibliography	5
4.	The media is equipped with illustrations and images that make it easy for readers to clarify the content.	5
Characteristics		
5.	E-module according to the five characters (self-instruction, self-contained, stand alone, adaptive, and user friendly)	5
6.	The suitability of e-modules that can facilitate the assignment of material	5
Language		
7.	Have clear legibility	4
8.	Consistency in the use of terms	4
9.	The language used is clear and communicative	5
10.	Spelling and grammar accuracy	4
Presentation		
11.	E-modules can be used independently and are not bound by time.	5
12.	Presentation of material is systematic and easy to understand	5
Material		
13.	The content of the material is in accordance with the learning objectives	5
14.	Material delivery is systematic and structured	5
15.	The material presented is in accordance with the facts in the field	5
Graphics		
16.	Font usage (type and size) is clear	4
17.	Has interesting and clear illustrations	4
18.	The media has an appropriate and harmonious layout and layout	4
PBL learning syntax		
19.	Orienting students to the problem	5
20.	Organizing students to learn	5
21.	Assisting independent and group investigations	4
22.	Developing and presenting work	5
23.	Analyzing and evaluating the problem-solving process	5
The percentage		93,9%

The validation result is in accordance with the "Very Valid" criteria or can be tested. Comments and suggestions given by the validator, namely that the media is interesting and easy to use, is suitable for testing.

2) Practicality

The result of the assessment of the practicality of the e-module media were carried out through a questionnaire for the student who were filled in after learning using the e-module. The following are the result of the student's responses after using the e-module media.

Table 10. Practicality Data on Field Test

No.	Assessment Aspect	Skor
Completeness of contents		
1.	The media is consistent with the learning objectives	5
2.	Media has the benefit of broadening students' horizons	5
3.	Media comes with a preface, table of contents and bibliography	5

No.	Assessment Aspect	Skor
4.	The media is equipped with illustrations and images that make it easy for readers to clarify the content.	5
Characteristics		
1.	E-module according to the five characters (self-instruction, self-contained, stand alone, adaptive, and user friendly)	4
2.	The suitability of e-modules that can facilitate the assignment of material	5
Language		
1.	Have clear legibility	4
2.	Consistency in the use of terms	4
3.	The language used is clear and communicative	4
4.	Spelling and grammar accuracy	4
Presentation		
1.	E-module can be used independently and are not bound by time.	5
2.	Presentation of material is systematic and easy to understand	5
Material		
1.	The content of the material is in accordance with the learning objectives	5
2.	Material delivery is systematic and structured	5
3.	The material presented is in accordance with the facts in the field	5
Graphics		
1.	Font usage (type and size) is clear	4
2.	Has interesting and clear illustrations	4
3.	The media has an appropriate and harmonious layout and layout	4
PBL learning syntax		
1.	Orienting students to the problem	5
2.	Organizing students to learn	5
3.	Assisting independent and group investigations	5
4.	Developing and presenting work	5
5.	Analyzing and evaluating the problem-solving process	5
The percentage		88,6%

The practicality test results obtained an average score of 88.6%. These results indicate that the *e-module* media developed is included in the "Very Practical" category and can be used by students.

3) Effectiveness

Field trials before using *e-module* media, students were asked to do *pretest* questions to measure the ability of students. After students use *e-module* media as learning media, students are also asked to do post-test questions. The following is a presentation of the pre-test and post-test results from the table below.

$$\begin{aligned}
 \text{Normalized Gain (g)} &= \frac{\text{posttest score} - \text{pretest score}}{\text{maximum score} - \text{pretest score}} \\
 &= \frac{74,7 - 45,35}{100 - 45,35} \\
 &= \frac{29,35}{54,65} \\
 &= 0,53
 \end{aligned}$$

Table 11. Effectiveness Result

Pretest	Posttest	N-Gain	Category
45.35	74.65	0.53	Medium

The effectiveness test of the *e-module* conducted resulted in an average pretest score of 45.35 and an average post-test score of 74.65 out of a maximum score of 100. The N-Gain score obtained was 0.53, which the medium effectiveness category. An *e-module* is considered effective if it has been evaluated by a team of faculty validators a received high score according to the achievement level. The validation process uses a Likert Scale modified by the author. Assigning score to each response. The response score is categorized as a follow: (4) very good, (3) good, (2) low, (1) very low. Summing the total scores from each validator for all statements. Providing a validation score according to the qualification.

B. DISCUSSION

The analysis stage has two stages, namely need assessment and front-end analysis. Needs analysis in the form of analyzing the situation in the field and students, and also collecting material references that are used as a subject matter in media development (Lee & Owens, 2004). The activity found that the learning model expected by students such as PBL, PJBL, TGT, Discovery Learning. The platforms that lecturers often use when teaching are the WA Group and the zoom platform with a percentage of 48.4% while those through the Sipejar (Learning Management System) is an online learning platform for State University of Malang Civitas with a percentage of 38.7%, of the two platforms the most prominent or the most frequently used in teaching lectures. The obstacles experienced by students in learning Plant Physiology courses in classroom learning are methods with a percentage of 29.6% and media with a percentage of 22.2% which is the most percentage of obstacles. Students are constrained by methods that are less able to increase student motivation, teaching materials and media provided can be added.

The design stage is material collecting (Collecting the materials needed to develop the media), making Storyboard, making a schedule in developing the media, determining the development team, determining media specifications, determining the content or content in the media, and preparing media validity and practicality test instruments. This media is applied with the PBL model, namely in the implementation of student learning as a facilitator or mediator, so that students have the opportunity to build their own knowledge and can improve their skills such as critical thinking (Hidayah et al., 2023).

The development stage is to create and develop e-modules from all components that have been prepared into one according to the storyboard that has been designed using software in the form of Canva, pdf, and flipbook applications. The disadvantages of this e-module media are that there is no audio, and the online flipbook only lasts for approximately 4 weeks so students have to download the PDF version. The media students can operate individually using their respective computers or laptops online. Validation to get an assessment and input on the development is accompanied by an e-module media validation assessment questionnaire.

In this implementation stage, the e-module media has been developed and tested for validity. The e-module media can be implemented to 3rd semester students majoring in biology and biology education at the State University of Malang. Implementation activities are known by the results of the pretest conducted before using the media and the results of the post-test conducted after using the media to determine the effectiveness of the e-module media. After using the media, students are asked to fill out a student response questionnaire sheet to find out the results of the practicality of the e-module media that has been used. Students in this learning have applied critical thinking skills in solving tasks or problems in the material in the e-module. The level of this skill varies from one student to another. The critical thinking of students with high, medium, and low abilities differs significantly in problem-solving (Loviasari & Mampouw, 2022). At the problem-understanding stage, students with high and medium abilities can articulate the known and asked information in the problems in detail. Students with high abilities are also capable of identifying irrelevant information and finding alternative solutions. However, students with medium and low abilities struggle to find alternative solutions. Students with low abilities are often unable to answer all questions correctly (Safitri, 2018).

The evaluation stage is carried out in the form of development evaluation and evaluation of validity, practicality, and effectiveness. The development evaluation is carried out by expert lecturers to determine whether or not the e-module media is suitable for use in learning media. The evaluation provides data that describes the quality of the media that is valid or invalid in use in learning media (Novianti et al., 2023). The results of the development of this e-module media have differences and similarities with previous research (Sagita et al., 2021) which can be used as further media development. The difference is that development research uses the 4D model (Define, Design, Develop and Disseminate) and the similarity with research is to improve PBL-based student critical thinking. Because these skills can help students to improve the quality of learning and e-modules are effectively used in current lectures.

4. CONCLUSION

Based on the research data developed and analyzed it can be concluded as follow: The e-module that has been developed is declared valid/worthy of use in plant physiology lectures. The development result is in accordance with the stages of the Lee & Owens model. The e-module was declared valid for use in plant physiology material. The result obtained by this validity consist of media validation obtaining 95% with the criteria "Veri Valid". Material validation obtained a value of 100% with the criteria "Very Varlid", and practitioner validation obtained a value 93,9% with the criteria "Very Valid". From the validations, the recapitulation result was declared "Very Valid". E-module usage is declared practical. The practicality results obtained 88.6% with the criteria "Very Practical". These results were obtained from the results of a questionnaire that had been filled in by students after using the e-module. E-module after being used in lectures, the results of pre-test and post-test that have been done by each student are obtained. The effectiveness results obtained a value of 0.53 which is included in the "Moderate" category of effectiveness. So, the e-module is declared effective in use in lectures.

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