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Development of E-Module Project-Based Learning (PjBL) Plant Diversity Based on the Local Potential of East Sumba Regency to Improve Critical Thinking Skills

Marleni Rosalia Ndapa Huda[1], Murni Sapta Sari [2], Dwi Listyorini[3]
[123] Biology Education, University of Malang, Indonesia

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ABSTRACT
This research aims to see the differences in the use of project-based learning e-modules based on the local potential of the East Sumba district on critical thinking skills. This research design uses research by Lee and Owens (2004). The research population was all SMA Negeri 2 Waingapu class X students for the 2023/2024 academic year. The samples were taken in 2 classes, namely 36 students for the experimental class and 36 for the control class. The analysis of critical thinking skills uses the ANCOVA test with a significance level of 5%. Based on the SPSS ANCOVA test output table, a significance value of 0.000 was obtained, which means it is smaller than α 0.05 (Sig < 0.05). This identifies that there are significant differences between classes that use e-modules and those that do not use e-modules. Therefore, it can be concluded that using the E-Module Project-Based Learning (PjBL) Plant Diversity Based on the Local Potential of East Sumba Regency significantly affects students' critical thinking skills.

Corresponding Author:
Murni Sapta Sari
Biology Education, University of Malang
Jl. Semarang 5 Malang 65145, Indonesia
Email: murni.sapta.fmipa@um.ac.id

1. INTRODUCTION

Education aims to create high-quality human resources. Education is important for students to achieve good social mobility (Xie & Zhang, 2020). Through education, an individual can develop skills to adapt to the demands of a world that continues to develop (Subri *et al*., 2012; van Laar *et al*., 2020). Critical thinking skills are important skills in the world of education that students must have.

Critical thinking skills are structured, rational, and reflective thinking needed to make intelligent decisions and produce quality thinking (Ramdiah & Corebima, 2014). Critical thinking skills are very important for students to have because they can help solve problems faced in everyday life. Therefore, students' critical thinking skills must continue to be developed through learning activities.

However, based on a preliminary study conducted through tests at 5 Senior High Schools (SMA) in the East Sumba district, the average percentage of students' critical thinking skills is 48 in the Low category. The results of the preliminary study on the critical thinking skills test at SMA Negeri 1 Waingapu had an average score of 50 (medium), SMA Negeri 2 Waingapu had an average score of 40 (low), SMA Kristen Payeti had an average score of 46 (low), SMA Negeri 1 Haharu had an average score of 60 (medium), and SMA Negeri 1 Kambera had an average score of 45 (Low). These results indicate that Indonesian education has challenges in improving critical thinking skills. Therefore, there is a need for transformation in the Indonesian education system to improve and advance the quality of education so that it is more inclusive and globally competitive.

Through studying biology, critical thinking skills can be trained (Snyder & Wiles, 2015). Biology is a very broad science and has many fields of scientific study. Each field studies different things about living things, from the cellular level to the level of more complex organisms (Campbell *et al*., 2014). One example is plant diversity, the subject of study in phase E-learning outcomes regarding the Diversity of Living Things. Students can learn contextually or directly in the surrounding environment and develop critical thinking skills (Ridhana et al., 2021). Learning activities involving the surrounding environment can help students recognize and utilize the local potential around them and utilize it wisely (Anisa *et al*., 2016; Prasetyo & Kristanto, 2015).

Local potential, especially plants, has a very close relationship with the people of Sumba. Sumba Island produces ikat weaving, which uses plants as natural dyes. Apart from that, the Sumbanese people also use plants as ingredients for traditional medicines, an important component of their customs. According to Hunaepi et al.,

(2019), learning activities that utilize local potential can help students develop a caring attitude about the environment.

However, based on the results of a preliminary study in the form of interviews with biology teachers at SMA Negeri 1 Waingapu, SMA Negeri 2 Waingapu, SMA Negeri 1 Kambera, SMA Negeri 1 Haharu, and SMA Kristen Payeti, it is known that learning activities have not utilized local potential. Therefore, there is a need for learning activities that utilize local potential to develop students' critical thinking skills.

Project-based learning (PJBL) has become an innovative approach in education, integrating learning concepts with everyday life and enabling students to develop practical skills. In learning activities using the PjBL model, students can carry out several stages, such as determining the project idea to be carried out, preparing a project plan, preparing an implementation schedule, implementing and completing the project, and evaluating/discussing project results (Krauss & Boss, 2013). These stages can help students to think critically (Anazifa & Djukri, 2017; Radcliffe *et al*., 2016).

E-modules can be used as a learning resource that facilitates the expression of East Sumba's local potential and the implementation of the project-based learning stages. E-modules are electronic teaching materials with the advantage of displaying images, audio, video, and animation (Sinta et al., 2020; Suarsana & Mahayukti, 2013). Students can use e-modules to learn independently, which can motivate them (Zahra et al., 2021). The integration of project-based learning and the local potential of East Sumba into the E-module is expected to increase the attractiveness of learning, stimulate students' sense of pride in the environment, create contextual learning, and improve students' critical thinking skills.

2. RESEARCH METHOD

This research type is development research, which consists of the stages of Assessment/analysis, Design, Development, Implementation, and Evaluation (Lee & Owens, 2004). The population in this study were all class X students at SMA Negeri 2 Waingapu, while the sample consisted of 36 control class students and 36 experimental class students who were chosen randomly.The research instrument used is a set of critical thinking skills questions validated by validators. Indicators of critical thinking skills refer to Finken and Ennis (1993), which consist of 1) focus, 2) supporting, 3) reasoning, 4) organization, 5) conventions, and 6) integration. The implementation uses a quasi-experimental design, as shown in Table 1.

Table 1. Quasi-experimental Design

Group	*Pretest*	Treatment	*Posttest*
E	O_1	X	O_2
K	O_3	-	O_4

Information:
E = Experimental group (treated)
K = Control group (not treated)
O_1= Pretest experimental group
O_2 = Posttest experimental group
O_3 = Pretest control group
O_4 = Posttest control group

Analysis of critical thinking skills using the ANCOVA test with a significance level of 5% is used to test hypotheses using students' pretest and posttest scores. Before the data is analyzed using the ANCOVA test, a prerequisite test is first carried out: the normality test using Kolmogorov-Smirnov and the homogeneity test using Levene's Test of Equality of Error Variance. Analyze the level of e-module effectiveness using N-gain with the formula and categories below:

$$\textbf{\textit{Normalized Gain}} = \frac{\boldsymbol{posttest\ score - pretest\ score)}}{\boldsymbol{maximum\ score\ (100) - pretest\ score)}}$$

Table 2. Category N-gain

No	N-Gain Score	Category
1	N-gain > 0,7	High
2	0,3 ≤ N-gain ≤ 0,7	Medium
3	N-gain < 0,3	Low

Source: (Hake, 1999)

3. RESULT AND DISCUSSION

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

***Assessment/Analyze* (analisis)**

The assessment and analysis stage consists of two main processes: need assessment and front-end analysis. The assessment needs analysis was carried out at five high schools in the East Sumba district, namely SMA Negeri 1 Waingapu, SMA Negeri 2 Waingapu, SMA Negeri 1 Kambera, SMA Negeri 1 Haharu, and SMA Kristen Payeti, through interviews with class X biology teachers. The needs analysis results showed that the teaching materials used are still limited to textbooks; they do not use electronic-based teaching materials; some schools use modules downloaded from the internet; and no schools use local potential as teaching materials.

Front-end analysis consists of several stages: 1) audience analysis, 2) technology analysis, 3) situation analysis, 4) task analysis, 5) critical incident analysis, 6) issue analysis, 7) objective analysis, 8) media analysis, 9) extant-data analysis, and 10) cost-benefit analysis. First, audience analysis aims to analyze students' obstacles or problems in learning activities, especially biology. This analysis was carried out using a critical thinking skills test using categories, according to (Riduwan, 2019). Based on the results of student analysis, it is known that the average critical thinking skills of students in 5 schools are still relatively low, namely 48. The results of the critical thinking skills test at SMA Negeri 1 Waingapu have a score of 50 (medium), SMA Negeri 2 Waingapu has a score of 40 (low), and SMA Kristen Payeti has a score of 46 (low), SMA Negeri 1 Haharu has a score of 60 (medium), and SMA Negeri 1 Kambera has a score of 45 (low).

Next, technology analysis aims to discover what technology teachers and students use in biology learning activities. Based on the results of the technology analysis, it is known that the five schools observed have adequate facilities for learning activities. For example, an internet connection is available; the average student has a cell phone, electricity, and other facilities needed for learning activities. Situation analysis aims to determine the condition of students' learning environment. The results of the situation analysis showed that the five schools observed had adequate capacity in terms of facilities and human resources. Task analysis aims to determine the type of assignment that is suitable to be applied to e-module development. Task analysis relates to the tasks of a team consisting of researchers or developers, supervisors, media experts, material experts, and field practitioners.

Critical incident analysis aims to determine critical things in this research, such as the type of skills that are the final goal of development, the materials used, and all the elements in the e-module so that the research focus is more clearly focused. At this stage, the material used is a diversity of living creatures created by combining local potential in the East Sumba district. Issue analysis aims to analyze problems that have been found in the field. At this stage, the researcher discovered the problems raised in this research: the unavailability of electronic teaching materials that utilize local potential and the lack of critical thinking skills. Objective analysis aims to determine solutions to the problems found. Based on the problems that have been identified, the solution to this problem is to create an e-module that focuses on plant diversity based on project-based learning. This e-module aims to improve students' critical thinking skills.

Media analysis aims to understand and determine the right media to support the learning process and overcome the problems found. Based on the needs analysis results, the product developed in this research is an e-module in the form of an application. Extant-data analysis aims to examine sources of information that have been collected, such as solutions that have been prepared based on data from interviews and questionnaires. Based on the results of this analysis, the researchers decided to develop an e-module project based on learning about plant diversity based on the local potential of the East Sumba district. Finally, cost-benefit analysis is carried out to understand the total costs required from the initial development stage to the final stage.

***Design* (desain)**

The design stage consists of several steps: 1) schedule, 2) project team, 3) media specifications, 4) lesson structure, and 5) configuration control and review Cycles. The implementation schedule for this research is as follows: 1) Analysis: June–July 2023; 2) Design: August 2023; 3) Development and Validation: September–October 2023; 4) Implementation: November–December 2023; and 5) Evaluation: December 2023.

The project team comprises researchers, supervisors, and validators consisting of media experts, material experts, and biology education practitioners. Each validator has criteria, including a minimum S3 (doctoral) education and a minimum teaching experience of 5 years for media experts and material experts, while field practitioners are biology teachers with a minimum of 5 years of teaching experience.

The Media Specifications in the developed E-module are an Android application containing images and videos connected with several supporting links. The E-module creation software is Website 2 APK Builder Pro and iSpring 11, while the software used to support typing E-module content or material is Microsoft Word, PowerPoint, and Canva.

The lesson structure in the E-module is prepared by the provisions of the Merdeka Curriculum, including analysis of the diversity of living creatures, identification of the characteristics of the diversity of living creatures, predominantly plants, the relationship between the diversity of living creatures and their functions and benefits, analysis of the causes of the loss of diversity of living creatures, and identification of solutions to threats to plant sustainability. This material is connected to the local potential found in the East Sumba district.

At the Configuration Control and Review Cycles stage, researchers control the E-module development process, ensure good quality, and complete it on time. The control process includes components such as text, links, and images, that are inserted or combined into the E-module.

Development

The development stage consists of three main steps: pre-production (*story board)*, production, and postproduction. Create an e-module storyboard by describing page layout, navigation, animation, text content, images, and interactive elements. Storyboards serve as a visual guide for planning the structure and appearance of e-modules, ensuring effective design and an adequate user experience. The production stage is an advanced stage for implementing the storyboard that has been designed. The content presentation is included in the production section. Material content, photos, videos, and additional designs are added as needed. After the e-module is produced, the next stage is validating the product with a validator and product testing.

Product validation involves media and teaching materials experts, material experts, and educational practitioners to ensure the quality and effectiveness of the e-module. Media experts validated the e-module with several revisions, resulting in the final validation as shown in Table 3.

Table 3. Validation of Media and Teaching Material Experts

No	Aspect	Score	Percentage (%)	Category
1	Feasibility of Presentation	4,9	97	Very Valid
2	Language Eligibility	5	100	Very Valid
3	Feasibility of E-module Design Graphics	5	100	Very Valid
4	Suitability of E-module Characteristics	5	100	Very Valid
	Average	**4,97**	**99**	**Very Valid**

Based on Table 3, the average percentage of e-module assessments assessed by media and teaching materials experts is 99%, a very valid category. This reflects the overall quality in terms of presentation, language, graphic design, and conformity with the characteristics of the e-module (self instructional, self contained, stand alone, adaptive, and user friendly), which are considered suitable for use in learning activities.

Next, validation by material experts was carried out through two stages of revision to achieve the results, as shown in Table 4.

Table 4. Validation of Material Expert

No	Aspect	Score	Percentage (%)	Category
1	Title Suitability	5	100	Very Valid
2	Example or Illustration	5	100	Very Valid
3	Images/Photos/Videos	5	100	Very Valid
4	Language	5	100	Very Valid
5	Depth/Breadth of Material	5	100	Very Valid
6	The Truth of the Concept of Matter	5	100	Very Valid
7	Updates on Material Concepts	5	100	Very Valid
8	Contextual Material	5	100	Very Valid
	Average	**5**	**100**	**Very Valid**

Based on table 4, the average percentage of material assessment in the E-module is 100%, which is a very valid category. The results of this validation have gone through two revision stages and met the standards set by material experts. This indicates that the material is reliable and can provide an optimal learning experience for its users. The next validator is a biology teacher who is a field practitioner in biology with a minimum criterion of teaching for five years.

Next is validation by biology education practitioners. The following is Table 5, validation results by biology education practitioners.

Table 5 Validation of Biology Education Practitioners

No	Aspect	Score	Percentage (%)	Category
1	Ease of use	4,80	96	Very Valid
2	Graphic Eligibility	4,86	97	Very Valid
3	Benefit	4,75	95	Very Valid
4	Effectiveness of Learning Time	5	100	Very Valid
	Average	**4,85**	**97**	**Very Valid**

Based on Table 5, the average percentage of E-module assessments by biology education practitioners is 97%, a very valid category. The results of this validation show that the e-module, from the aspects of ease of use, graphic feasibility, benefits, and effectiveness of learning time using the e-module, is classified as very good and can be used in learning activities.

After the e-module is validated, product trials are then carried out. Product trials were conducted at schools that were not research subjects, namely at SMA Negeri 1 Waingapu. Product trials were carried out three times: *one to one trial*, *small group trial*, and *field trial*. The results of the One to one trial, small group trial, and field trial product trials were 94, 94, and 92, respectively, which are classified in the very practical category, as seen in Table 6.

Table 6. Product Trial

No	Product Trial	Number of Subjects	Average		Category
			Score	Percentage	
1	One to one Trial	3	4,70	94	Very Practical
2	Small Group Trial	11	4,72	94	Very Practical
3	Field Trial	30	4,59	92	Very Practical
	Average		**4,67**	**93**	**Very Practical**

Implement

The implementation stage aims to determine the effectiveness of the E-module project-based learning on plant diversity based on local potential in the East Sumba district, which has been revised and validated in the previous stage. At this stage, the e-module will be introduced to students as a learning tool used in biology subjects regarding biodiversity. Implementation was carried out in control and experimental classes, each with 36 students. The following are the results of students' critical thinking skills tests in the experimental and control classes via pretest and posttest.

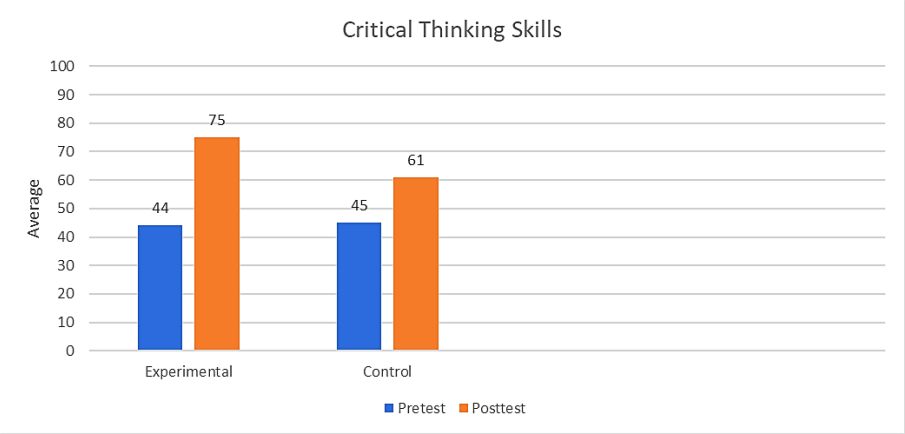

Figure 1. Average Value of Critical Thinking Skills

Based on Figure 4.1, which presents the results of the pretest and posttest, it is known that the experimental class had an average score on the pretest of 44, while on the posttest, it increased to 75. Meanwhile, the control group had an average pretest score of 45, which increased to 61 in the posttest. With the changes in scores from pretest to posttest, it can be concluded that the experimental group experienced a more significant improvement than the control group.

Evaluate

Knowledge evaluation was conducted to determine the effectiveness of the e-module implemented in the control and experimental classes. The data was analysed based on the Anova test, which previously carried out the prerequisite tests for normality and Homogeneity. Normality test results show that the significance value of pretest and posttest critical thinking skills is greater than 0.05. Therefore, the pretest and posttest data variants are normally distributed, as shown in Table 7.

Table 7. Kolmogorov-Smirnov Normality Test

Group	Significance	Distribution
Pretest Experiment	0,180	Normally Distributed
Posttest Experiment	0,066	Normally Distributed
Pretest Control	0,200	Normally Distributed
Posttest Control	0,166	Normally Distributed

The results of the homogeneity test show that the significance value of the pretest and posttest critical thinking skills is greater than 0.05 (Sig > 0.05). Therefore, the pretest and posttest data variants are homogeneous, as shown in Table 8.

Table 8. Homogeneity Test

Statistic	***Pretest***	***Posttest***
Levene Statistic	1.222	0.090
df1	1	1
df2	70	70
Sig.	0.273	0.765
Conclusion	**Homogeneous**	

The results of the ANCOVA test show that the significance value of critical thinking skills is greater than 0.05 (sig > 0.05). Therefore, the pretest and posttest data variants are homogeneous, as seen in Table 9.

Table 9. ANCOVA Test

Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Corrected Model	5008.469[a]	2	2504.234	50.799	.000	.596
Intercept	6028.553	1	6028.553	122.290	.000	.639
Prettest	124.455	1	124.455	2.525	.117	.035
Class	**5003.966**	**1**	**5003.966**	**101.506**	**.000**	**.595**
Error	3401.517	69	49.297			
Total	356049.000	72				
Corrected Total	8409.986	71				

Based on the SPSS ANCOVA test output table, a significance value of 0.000 was obtained, which means it is smaller than α 0.05 (Sig < 0.05). This identifies significant differences between les classes qui utilisent e-modules et celles qui doivent ne pas utiliser e-modules. Therefore, it can be concluded that using the E-Module Project-Based Learning (PjBL) Plant Diversity Based on the Local Potential of East Sumba Regency significantly affects students' critical thinking skills.

The evaluation results using N-gain showed increased scores for the experimental class from the pretest to the posttest. The N-gain score for the experimental class was 0.55, which shows that the effectiveness of using the E-Module Project-Based Learning (PjBL) Plant Diversity Based on the Local Potential of East Sumba Regency is in the medium category, as seen in Table 10.

Tabel 10. N-gain Score

Group	**Average**		**N-Gain**	**Effectiveness Category**
	Pretest	**Posttest**		
Experimental	43.72	75.17	0.55	Medium
Control	45.36	61.25	0.28	Low

Based on a series of analyses that have been carried out, the E-module with a Project-Based Learning (PjBL) approach, which focuses on local potential, has a significant positive impact on improving students' critical thinking skills. E-modules can function as a guide that provides direction and resources to complete projects, supporting the development of students' critical thinking skills throughout the learning process (Mutakinati et al., 2018). The e-module has a good impact on improving students' critical thinking skills. Through this innovative learning approach, students receive passive information and are actively involved in developing critical thinking. The e-module presents learning materials interactively and encourages active participation, thereby creating an environment that stimulates the development of students' critical thinking skills.

The projects in the e-module enable students to gain theoretical knowledge, connect concepts, and make decisions based on in-depth understanding. PjBL creates a learning context that hones students' critical thinking skills and allows students to solve problems and develop relevant insights in everyday life (Wibowo et al., 2018). PjBL aims to provide meaningful learning experiences, enabling students to develop skills, knowledge, and a deep understanding of the topics studied (Kean & Kwe, 2014; Ntombela, 2015). In project-based learning, students become the main subject, and the project becomes the core of the learning process so that students can understand the problems they are working on in the project (Afriana et al., 2016). Therefore, through learning that uses project activities, students can think critically to understand a problem and provide solutions to it.

Learning to utilize local potential is essential to developing students' critical thinking skills. Learning activities that involve the surrounding environment or local potential can motivate students to think critically

about the differences, similarities, and implications of the concepts studied in everyday life (Anisa, 2017). This helps form an analytical mindset, problem-solving skills, and sharper evaluation skills because students actively respond to and interpret the reality around them. Therefore, learning that utilizes local potential enriches students' learning experiences and provides a strong foundation for developing critical thinking skills to face future challenges.

The integration of PjBL and the local potential of East Sumba in the e-module ensures that the projects or assignments given are not only relevant but also closely related to students' daily lives. With the help of e-modules, this local context can be presented in learning materials, increasing students' connection to learning topics and motivating them to think critically. Overall, integrating the PjBL e-module based on local potential is effective for students to stimulate the development of critical thinking skills through applying concepts in real-life contexts and utilizing local resources.

4. CONCLUSION

Based on the ANCOVA test, a significance value of 0.000 was obtained, which means it is smaller than α 0.05 (Sig < 0.05). Therefore, it can be concluded that using E-Module Project-Based Learning (PjBL) Plant Diversity Based on the Local Potential of East Sumba Regency significantly affects students' critical thinking skills. The N-gain test results show that the level of effectiveness of the e-module is in the medium category with a value of 0.55.

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