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The Development of Electronic Modules Based on Problem Based Learning Integrating Disaster Mitigation in Environmental Change Material to Increase Critical Thinking Skills of Students

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ABSTRACT
An e-module is a learning media designed to assist students in discovering and solving problems independently and can be used practically and flexibly. The purpose of this paper is to produce a PBL-based integrated disaster mitigation e-module on environmental change material that is valid, practical and effective. The e-module development used the development model by (Lee & Owens, 2004). E-modules were validated by material experts, learning media experts, biology education experts and practitioners. Furthermore, the e-modules were tested on students in individual, small group and field trials. In the field trial, the e-module was applied in biology learning. Based on the N-Gain test score between pretest and posttest, it is known that the experimental class is in the high category and the control class is in the medium-high category. The results prove that the e-module developed is valid, practical and effective, so it can be used in learning activities that can improve students' critical thinking skills.

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1. INTRODUCTION

The rapidly expanding technology and science in the current 21st century, requires all students to increase their quality to be able to compete and build skills in reaching the flow of scientific advance (Wahyuni et al., 2020). The skill of the 21st century students must able to master are creative thinking, critical thinking, collaboration and communication (Miterianifa et al., 2019). These skills need to be applied in all learning activities at school, especially Biology lessons. Biology is one of the sciences which is the basis for science. But on the other hand, science is also considered to be difficult. In addition, student learning in schools is only an obligation in carrying out the curriculum, which should be in carrying out learning activities cannot be separated from the relevance to the real world which is the object of knowledge of the knowledge itself (Ardiyanti, 2016). Biology material consists of the knowledge, abilities, and attitudes that should be learned in detail. In more detail, biology topics contain information that contains of concepts, facts, procedures, and principles. To master and analyze biological material, students must be able to understand the material not just memorize the material. To be able to understand the material and concepts in biology, higher skills are required (Made, 2013). One of the high-level thinking skills needed is critical thinking (Agnafia, 2018).

Critical thinking is a competency as a combination and mobilization of knowledge, attributes, skills, attitudes and the value that is developed when solve problems. Such problems should arouse students' natural curiosity and stimulate learning and critical thinking. Critical thinking also represents the intellectual processes, tactics, and representing used by people to problem-solve, decision-making, and new learning concepts. (Lai, 2011; Thornhill-Miller et al., 2023). Critical thinking also refers to a person's ability to develop and explain arguments from data made into complex decisions or ideas (Agnafia, 2018). According to Ennis, 1985, critical thinking indicators consist of five groups, namely: basic clarification; building basic skills; interference; advanced clarification; Organizing strategies and tactics (Ennis, 2011, 2013, 2016). To improve critical thinking in schools, one alternative way is to apply a learning model that can improve critical thinking among students, namely PBL (Rahmah et al., 2019).

PBL is a model of learning that comes from problems to be solved by students (Purwanto et al., 2016). PBL is a teaching model that applies real life issues as a content to help students engage in critical thinking and problem solving skills, and to gain essential concepts and knowledge from the subject matter (Prasetya et al.,

2017). Model PBL is a teaching model which leads to critical thinking that is expected to improve the critical thinking skills of students. Furthermore, PBL helps students to improve their problem solving and thinking skills, learn adult roles and be independent learners (Arends, 2006; Rahmah et al., 2019). So, this learning model can be utilized to increase students' critical thinking skills. Through PBL, students are required to be capable of solving problems with a variety of alternative solutions and identifying the causes of the existing problems (Nadeak & Naibaho, 2020).

One important factor to increase critical thinking through reading is the e-module (Muzijah et al., 2020; Suarsana & Mahayukti, 2013a). The developed module is then implemented in learning activities, in each activity it is connected to a more interactive link with the presentation of video, animation and audio is an e-module. E-modules are interactive, make navigation easier, display/ show images, audio, video and animation and are equipped with formative tests/quizzes that allow immediate feedback (Suarsana & Mahayukti, 2013b). Learning activities in the e-module are made based on the stages of the PBL model visualized by the features contained in the e-module: 1) The feature of observing the video that illustrates the form of the step of orienting students to the problem, 2) The info review feature is that students will be asked questions which is a description of the step of organizing students to learn, 3) The let's investigate feature is a description of the step of assisting students in conducting investigations or experiences individually or in groups 4) The speak up feature is a description of the step of developing and presenting work from activities in the previous step, 5) The should you know feature is a step of analysing which contains a description of the material as a reference for the series of learning that has been done and 6) The explore your knowledge feature contains practice questions to measure students' abilities after doing learning activities which is a description of the evaluation step of the problem solving process (Kimianti & Prasetyo, 2019).

Environmental change material is material that is suitable to be delivered with a PBL model. A characteristic of PBL is authentic problems, where problem learning requires students to conduct authentic investigations to solve real problems. One of these real problems is the problem of environmental change and pollution that occurs around where students live. Environmental change is material that exists in KD 3.11, namely analyze data on changes in the environment, its causes and impacts in life and 4.11 formulate solutions to environmental change problems that occur in the environment in grade X high school even semester. The material of environmental change is material not only focused on Biology lessons, but also Geography, Social Studies and also disaster knowledge. In disaster knowledge, it is included in disaster mitigation or activities carried out to provide education to reduce the risk of impacts caused by disasters. In disaster mitigation, the material is divided into 3 phases, which are: pre-disaster, during disaster and post-disaster. The activity of disaster mitigation is closely related to the biology of environmental change. Where each stage includes material in environmental changes such as pre-disaster, it contains activities and activities that must be carried out to prevent natural damage that can cause disasters.

Based on the description that has been explained, the purpose of this study is to develop learning media products such as E-modules based on PBL Integrated Disaster Mitigation on Environmental Change Material to Increase Students' Critical Thinking which are effective, practical, and valid.

2. RESEARCH METHOD

This development research aims to develop PBL-based learning media integrated with disaster mitigation. The development of e-modules was carried out using the development model (Lee & Owens, 2004) which consists of 4 stages, namely: 1) Multimedia needs analysis and assessment, 2) Multimedia instructional design, 3) Multimedia development and implementation, and 4) Multimedia evaluation. The research will be conducted using a quasi-experimental method with a pretest-posttest control group design. The e-module validity data results were analyzed with the following calculations and validity criteria:

$$\textbf{\textit{Score}} = \frac{\sum \textit{scoreobtained}}{\sum \textit{item total}}$$

The results of these calculations are then matched with the validity and practicality criteria according to Table 1.

Table 1. The criteria to assess the validity of the development product

No	Validity Criteria	Level of Validity
1	X=5	Very valid and can be used without revision
2	$4 \geq X < 5$	Valid and can be used with minor revisions
3	$3 \geq X < 4$	Less valid and recommended not to use, moderate revision
4	$2 \geq X < 3$	Invalid, major revision and should not be used
5	$1 \geq X < 2$	Very invalid, should not be used, total revision

(Source: Andri Aka et al., (2018))

The results of student responses to the usage of e-modules can be calculated using the following calculation:

$$\textbf{\textit{Score}}= \frac{\sum scoreobtained}{\sum item\ total}$$

The criteria for the practicality of e-module products can be seen in Table 2 below.

Table 2. Criteria for assessing the practicality of e-module products

No	Validity Criteria	Level of Validity
1	X=5	Very practical and can be used without revision
2	4 ≥ X <5	Practical and can be used with minor revisions
3	3 ≥ X <4	Less practical and recommended not to use, moderate revision
4	2 ≥ X <3	Not practical/ major revision and should not be used
5	1 ≥ X <2	Very impractical and should not be used, total revision

(Source: Andri Aka et al., (2018))

The data of critical thinking analysis results are pretest and posttest. The instrument used to evaluate the results of students' critical thinking is an assessment rubric developed by (Zubaidah, 2017). The critical thinking indicators used in this study are: 1) Provide a simple explanation, 2) Building basic skills, 3) Concluding, 4) Providing further explanation and 5) Developing tactical strategies (Ennis, 2016). The results of the critical thinking score were obtained from the test results of the experimental class using the e-module and the control class without using the e-module. Furthermore, the score results were tested using the N-Gain score test. The advantage of using N-Gain is that it can distinguish the impact of treatment/learning (in this study is the use of e-module of environmental change) and does not depend on the population and students' initial knowledge/ pretest score. N-Gain was used in the study to determine the effectiveness of e-module of environmental change on thinking skills in biology class XI high school. This is to present an overview of the increase in critical thinking scores obtained in experimental and control classes before and after the learning process. The following is the formula for the N-Gain test:

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

The criteria for the N-gain value can be seen in Table 3 below.

Table 3. the criteria of N-Gain improvement

N-gain Score	Classification
$(g) < 0{,}25$	Low
$0{,}25 \leq (g) < 0{,}45$	Low-Medium
$0{,}45 \leq (g) < 0{,}65$	High-Medium
$(g) \geq 0{,}65$	High

(Source: Sutopo & Waldrip., (2014))

3. RESULT AND DISCUSSION

E-module development based on PBL integrated with disaster mitigation is arranged to assist students in finding sources of information independently. E-modules also have a function as teaching materials that can streamline time in teaching, teachers act as facilitators and so the process of learning becomes interesting and interactive (Prastowo, 2015). The e-module developed is designed to assist learning activities in a classroom that contains a set of systematically designed materials, methods, boundaries and evaluation tools to reach the competencies expected based on the level of electronic complexity (Kimianti & Prasetyo, 2019). In this study, the competency achieved is critical thinking skills in students trained through PBL activities included in the features of learning activities in e-modules. The advantages of e-modules for learning activities are that they can improve effectiveness and learning flexibility, are not limited by space and time, make the process of learning more attractive and do not get bored quickly because e-modules supported by media such as images, videos, and

interesting features (Umma et al., 2017). E-module development is customized to student needs. The reason for the development is because e-modules are self-contained, self-instructional, and adaptive, as well as user friendly. The e-module is self-instructional because the material compiled is Environmental Change Integrated with Disaster Mitigation. The material explains specifically about the achievements of environmental change material which is associated and collaborated with disaster mitigation material which includes pre-disaster, during disaster and post-disaster activities. The material is presented along with information from the web and images that support learning activities. E-modules are also self-contained because the contents of the e-module contain: menu list, instructions for use, material per sub chapter, material evaluation for each chapter, student worksheets, PBL features, disaster mitigation features, evaluation questions that can be done online using the web quiz provided through the link. The e-module is prepared by presenting the phenomena of environmental change, pollution, and natural disasters, especially floods that occur around students. Based on these reasons and considerations, the e-module prepared can facilitate students in mastering environmental change material in everyday life.

E-modules have been reviewed by the material validators, media experts, biology education experts and field practitioners. A summary of quantitative data from the results of the validation by the four validators is shown in Table 4. Based on the table, the results of the assessment of the feasibility of e-modules by material experts get a score of 4 with a valid category. On the results of the feasibility of e-modules by media experts get a score of 4.62 with a valid category. In the education expert validator obtained a validation score of 4.62 with a valid category and the results of validation by field practitioners obtained a score of 4.52 with a valid category. The results of the four validators were then averaged to produce an average validation score of 4.44 with a valid category, and can be used with minor revisions. Based on this score, the conclusion is that the developed disaster mitigation integrated PBL e-module can be used with minor revisions. Minor revisions by validators included as qualitative data such as comments and recommendations from validators are listed in Table 5.

Table 4. The results of the feasibility assessment by validators

No	Validators	Score	Description
1	Material Expert	4	Valid and can be used with minor revisions
2	Media Expert	4,62	Valid and can be used with minor revisions
3	Education Expert	4,62	Valid and can be used with minor revisions
4	Field Practitioners	4,52	Valid and can be used with minor revisions
	Average	4,44	Valid and can be used with minor revisions

Table 5. Comments and suggestions by validators

Validator	Comments and Suggestions
V1	It is recommended to add disaster mitigation material from journals, not only from BNPB books. Also deepen the disaster mitigation material. Improve the subtitles in chapter 1 of the e-module.
V2	Improving the evaluation questions based on revisions in the corrected draft.
V3	Added objectives to the e-module. Added self-assessment activities to the learning activities.
V4	Corrected some sentences in the material section that could cause misconceptions.

These results produce e-modules in valid criteria so it is concluded that e-modules are usable with minor revisions given by the validator on the validation instrument. The results of the validation of the e-modules developed are in accordance with the standards so that the e-modules are considered good teaching material criteria. This is supported by the statement that the developed e-module must be in line with its objectives, e-modules said to be good if they can support learning activity content (Muzijah et al., 2020).

After making revisions on the validation results of comments and suggestions from the validator. Then the e-module practicality test was tried on through three group, namely individual tests, small group tests and field tests which can be seen in Table 6. The individual test conducted on 3 students in class XI MIPA who have taken biology lessons on environmental changes resulted in a score of 3.44 which is classed on less valid category and moderate revision. After conducting the individual practicality test, researchers made revisions based on comments and suggestions. The revised e-module results from the individual test were then tested again in a small group with a total of 10 students. The results of the validation score from the small group test increased, which was 4.10 greater than the individual score with a valid category, with minor revisions. After conducting a small

group test and making revisions based on suggestions and comments, then a large group test was conducted with 27 students which resulted in a score of 4.61 with a valid category, usable with minor revisions. Based on the three tests that have been carried out, it is known that the e-module practicality test score has increased, which can be seen in Figure1. E-module practicality test show that the product is practical dan be able to use in learning activities.

Table 6. Results of E-module Practicality Test

No	Test subject	Number of subjects	Score	Category
1	Individuals	3	3,44	Less practical, not recommended for use, moderate revision
2	Small group	10	4,10	Practical, can be used with minor revision
3	Large group/field	27	4,61	Practical, can be used with minor revision

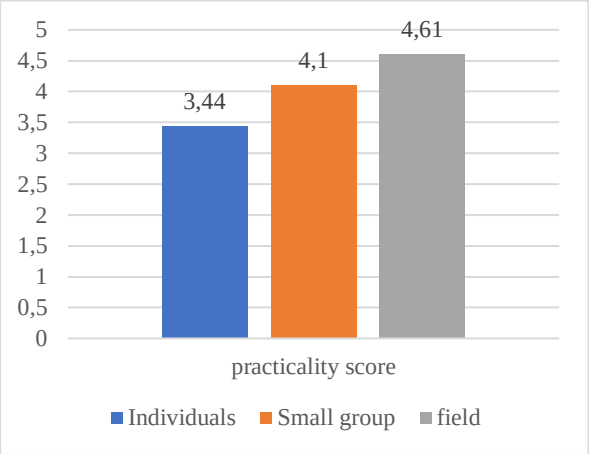


Figure 1. E-module practicality test score

The results of the practical e-module test can be concluded that the e-module based on PBL integrated with disaster mitigation really helps students in the learning activity, especially in environmental change topic, is able to make students more active and can make students learn independently anywhere and anytime using e-modules. In line with Praswoto (2015) the function of teaching materials is to be able to optimize time in teaching, as well as to make the learning process interactive and interesting. Seruni et al., (2020) states that e-module can make students act as the center of learning, where the teacher trusts students as facilitators who actively solve problems and build their knowledge by discussing in groups. The direct benefit that can be felt by users the developed e-module is that students gain increased knowledge both in terms of biological science, disaster science and technology used.

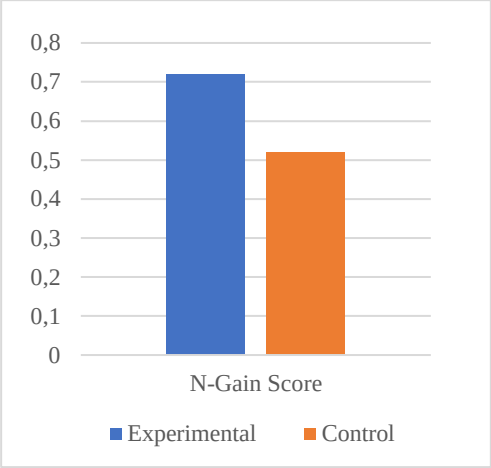
The effectiveness test on the e-module to measure critical thinking can be used the N-Gain. The test aims to find out the improvement of students' critical thinking scores after being given e-module treatment in learning activities. The data used to test the increase is scores of pretest and posttest. The results are the experimental class was 0.72 which according to the classification is high. Meanwhile, the control class was 0.52 according to the medium-high classification. The result of N-Gain test is shown in Table 7.

Table 7. N-Gain test results

No	Class	Skor N-Gain	Criteria
1	Experimental	0,72	High
2	Control	0,52	High-Medium

According to the analysis of N-Gain data, the average of two classes is known and proven that there is significant difference between experiment class and control class. The learning using PBL e-modules integrated with disaster mitigation provides better results by getting a high category, especially in the aspect of students' critical thinking which is depicted in the chart in Figure 2 below:

Figure 2. N-Gain score of students' critical thinking



E-module effectiveness in this study was evaluated from students' critical thinking tests through classroom learning activities. Learning was carried out using two classes. The first classroom is an experimental class where learning uses the PBL model and uses the developed disaster mitigation integrated PBL e-module, while the second is a control class that only uses the PBL model without the e-module. The learning was conducted to find out the effect by using e-modules in improving students' critical thinking in accordance with the aims of the e-modules. The gain test in the experimental class amounted to 0.72 which according to the classification is classified as high. As for the control class of 0.52 which is according to the medium-high classification. In accordance with the description that has been presented, the conclusion is that the use of e-modules obtained a high classification when used in learning activities and was able to increase the critical thinking of students. While learning without e-modules is classified as medium-high. So that using PBL-based e-modules integrated with disaster mitigation in classroom learning activities on environmental change material is more effective than learning without e-modules. This is supported by the statement in Suarsana & Mahayukti, (2013) which states that learning based on real problems or PBL is an effective model for teaching high-level thinking processes including critical thinking in it. Aufa et al., (2021) also added that the use of PBL based e-module in the learning process can provide in depth understanding of cognitive, effective and psychomotor domains that support improving critical thinking that improve student learning outcomes. Thorndahl & Stentoft, (2020) also state PBL can improve critical thinking skills because it explicitly and actively engages students in a system of learning and teaching, characterized by cycles of repetition. A PBL learning system is characterized by iterative and reflective cycles in learning specific knowledge and students engage in the thinking process for themselves.

4. CONCLUSION

The conclusion resulting from the development of PBL e-modules integrated with disaster mitigation on the material of environmental change biology class X in senior high scool is to produce a valid product with an average score of 4.4 with a valid category and feasible to use. Furthermore, the e-module developed produces a practical e-module that can be used in learning activities. E-modules are also effective in learning in terms of improving students' critical thinking skills. According to the N-Gain test of critical thinking skills of students, the experimental class result of 0.72 was higher than 0.52 in the control class. The category of N-Gain value in the experimental class is high and the control class is medium-high.

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