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Development of Electronic Modules (E-Modules) Based on Problem Based Learning on Additives and Addictive Substances to Improve Students' Critical Thinking Ability

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Abstract: The purpose of this study was to determine the characteristics, feasibility, and effectiveness of the E-module of additives and addictive substances based on problem-based learning in order to improve students' ability to think critically. The type of research used is development research, which refers to the Borg and Gall development model which is modified and adapted to conditions in the field into 9 stages, namely: 1) needs analysis and information gathering, 2) potential problems in the field, 3) product design, 4) design validation, 5) product design improvement, 6) limited trial, 7) product revision, 8) operational field test, 9) E-module final product. The data analysis technique used is a descriptive analysis which is used to describe the characteristics of the developed E-module, the feasibility analysis of the E-module is based on the N-gain score obtained, the results of this study found that the problem-based learning-based E-module has been successful developed according to the problem-based learning model to improve the ability of students to think critically. Problem-based learning-based E-modules are very feasible to be used in the process of learning activities in order to improve students' critical thinking skills. E-module of additives and addictive substances based on problem-based learning has been effective in improving the ability of students to think critically which is marked by an increase in students' pretest and posttest scores, and based on the average result of the N gain score of 0.76 which is included in the very decent category.

Keywords: Problem-Based Learning Module; Critical Thinking; E-Module.

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Introduction

The quality of human resources from time to time is increasingly required to continue to develop in accordance with the development of an increasingly advanced era in the 21st century. In this 21st century everything is based on technological progress and almost all aspects of life are digital based. Efforts to improve the quality of quality human resources are closely related to the quality of Natural Science education taught in the process of learning activities.

The learning process of Natural Sciences focuses more on providing direct experience to students, it aims to develop the competence of students to better understand the natural surroundings scientifically (Ali, 2018). Natural Science learning today must be oriented towards developing 21st century skills, where these skills are special skills that are indispensable to face the 4.0 revolution era which fundamentally changes the way of life of humans as a whole in accordance with advances in digital technology (Zulaichah, et al., 2021).

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One of several components that can support 21st-century skills in the field of education is the innovation of new teaching materials or teaching media, which can support learning activities, especially digital-based ones, namely electronic modules (E-modules). Based on the needs analysis that has been carried out by means of direct observation, giving questionnaires, and direct interviews with science teachers for class VIII, it shows that teachers and students have never known what an electronic module (E-modules) is that supports teaching and learning activities in the classroom. The teaching materials used by students are only in the form of textbooks or handbooks that are lent by each school 1 for each student. This shows that the handbooks used by students have not been able to support digital learning and have not trained 21st-century skills.

The ability to think critically is one of the 21st century skills that must be developed to face the 4.0 or 21st century revolution era (Zubaidah, 2018). The ability of students to think critically is needed to process information that is true or false, worthy of being accepted or should be rejected (Priyadi, et al., 2021). One of the characteristics of a good education is to prepare students to be able to solve problems and challenges that occur in real terms in the real world (Sadhu & Laksono, 2018). The ability to think critically can be interpreted by thinking logically and reflectively or using a hypothesis or tentative assumption of a decision to be taken to solve a problem at hand. Critical thinking is an ability that cannot be separated from learning activities because critical thinking skills are a very important cognitive ability in student learning activities (Ennis, 2011). Activities that can improve students' critical thinking skills include activities to analyze problems, identify processes, examine, differentiate a concept, select, and develop a good knowledge (Dewi & Prasetyo, 2016).

In accordance with direct observations that have been carried out at SMPN 2 Tlogomulyo, Temanggung, it was found that students' critical thinking skills are low. The low ability of students to think critically can be due to learning that is still teacher centered or centered only on the teacher. During learning activities, the teacher only conveys material using the lecture method, so students are accustomed to only taking notes on what the teacher says without digging deeper knowledge. In addition, when the teacher asks questions to the students, only 1 or 2 children dare to answer questions and express their opinions, so that during the learning process the students tend to be passive. Based on the problems found, critical thinking skills must be trained and also improved, to improve students' critical thinking skills, student-centered or student-oriented learning should be carried out and also familiarize students to get used to solving a problem. One of the learning models that can be applied to accommodate problems regarding students' low critical thinking skills is to apply problem-based learning, or known as problem-based learning (Diana, et al., 2015).

Problem-based learning activities or problem-based learning is a learning model that can improve students' critical thinking skills because the learning focuses on giving problems at the beginning of learning, students who are familiar with problem-solving will stimulate their ability to think critically (Bashith & Amin, 2017). For the students who learn to use the Problem-Based Learning model, their critical thinking skills will be higher than students who learn to use the lecture or teacher-centered method (Wulandari & Surjono, 2013). Problem-based learning can be applied through group discussions, namely at the research and investigation group stage, at this stage, it can train students to exchange ideas between individuals and their group of friends in order to solve the problems they face. Through a process of discussion, question and answer, and exchanging ideas with their group friends, they are able to build their knowledge about the material being taught.

The application of problem-based learning activities or problem-based learning that can stimulate students' critical thinking skills can be supported using an appropriate learning resource or teaching media, namely an electronic module (Diana et al., 2015). Electronic modules can be formed and arranged according to the syntax of the problem-based learning model in the form of giving problems or problem orientation to students, then organizing students to investigate, help carry out investigations in groups, develop knowledge and present the results of the investigation, then conduct research analyze and evaluate the problem-solving process that has been presented earlier. The benefits of using electronic modules based on problem-based learning models or orienting students to a problem can help students to practice their ability to think critically and also help students to build scientifically correct knowledge or concepts (Suarsana & Mahayukti, 2013).

Based on the results of observations and interviews with the VIII Grade Science Teacher of SMPN 2 Tlogomulyo, Temanggung Regency, along with the VIII grade students, one of the materials that is difficult for students to understand is science material, especially Additives and Addictive Substances. The material for additives and additives is contained in Basic Competency 3.6 which explains additives in food and beverages that are consumed daily, addictive

substances that are harmful to health and not harmful to health, as well as adverse effects as well as prevention efforts from the abuse of prohibited substances, where the material is very important to motivate students to stay away from prohibited substances such as narcotics and psychotropic substances. Additives and addictive substances are close to everyday life or students' real experiences, so students must be faced with a problem based on real facts related to everyday life (Rostikawati & Permanasari, 2016). Therefore, the development of an electronic module (E-modules) based on a problem-based learning model on additives and addictive substances is expected to improve students' ability to think critically. This study has three problem formulations which include: 1) the characteristics of the E-module of additives and addictive substances based on problem-based learning, 2) the feasibility of the E-module of additives and addictive substances based on problem-based learning, and 3) the effectiveness of the E-module problem-based learning-based additive and addictive substance modules.

Method

This research belongs to the type of research development or Research and Development, the model used in this research is the development model from Borg and Gall which has been modified according to the conditions in the field, which includes: 1) needs analysis and information gathering, 2) potential problems in the field field, 3) product design, 4) design validation, 5) product design improvement, 6) limited trial, 7) product revision, 8) operational field test, 9) E-module final product.

The first stage of this research is to analyze the needs of students and teachers in schools and collect some of the information needed to develop this research. This is followed by drawing some potential problems that can be used as the background of this research, and the product design stage is carried out to produce E-modules that are in accordance with the characteristics and syntax of problem-based learning that are integrated with students' critical thinking skills. Then for the design or product validation stage, it is carried out to obtain evaluation and improvement of the developed E-module, the validator consists of several expert fields, namely media, materials, language, and learning expert validators, each of which consists of two validators in each field in accordance with each other's expertise. A limited trial was conducted to test the readability of the developed e-module, the subjects of this limited trial were 31 students of class VIII (Class VIII A) SMPN 2 Tlogomulyo, Temanggung Regency.

The operational field test phase was carried out to determine the effectiveness of problem-based learning-based E-modules to improve students' ability to think critically. The subject of this operational field test is an E-module based on problem-based learning and also 88 class VIII students of SMPN 2 Tlogomulyo, Temanggung Regency. This operational field trial phase uses a one-group pretest-posttest design where there is an initial test before being given a treatment, then given a test again after being given treatment. The results of a treatment can be known accurately because it can show the results of the comparison between before being given treatment and after being given treatment (Fitrianingsih & Musdalifah, 2015). The operational field test design is presented in Table 1.

Table 1. One group pretest – posttest design

Class	Pretest	Treatment	Posttest
Experiments	O_1	X_1	O_2

(Sugiyono, 2012)

Description:
X_1 = Treatment by applying E-module Problem Based Learning
O_1 = Pretest value before treatment
O_2 = Posttest value after treatment

The population of this study was all students of class VIII which consisted of 4 study groups, namely class VIII A, VIII B, VIII C, and VIII D totaling 119 students. The research instruments used in this study were the E-module validation sheet (media, materials, language, learning experts), teacher response questionnaires, student response questionnaires, teacher interview sheets, student interview sheets, and students' critical thinking ability test instruments.

The critical thinking test instrument used for the pretest and posttest questions had previously been empirically validated for classes that had received additives and addictive substances, which involved 24 students in class IX B. Then an assisted analysis was carried out with the IBM SPSS Statistic 22 application using Product Moment sign correlation 0.05, which consists of reliability test and validity test. The type of test used to test students' critical thinking skills is to use essay questions (Kusuma, et al., 2017) because if an assessment is carried out in the form of multiple-choice questions it can be possible that students choose answers that are less appropriate, then it is better using an assessment or test in the form of an essay (Istiyono, et al, 2019).

The characteristics of the problem-based learning-based E-module developed in this study were

analyzed using descriptive analysis methods. The feasibility of the problem-based learning-based E-module that was developed was analyzed based on the validation results given to expert validators which included validation of language, materials, media, learning experts, each of which consisted of two expert validators in each field. The criteria for the feasibility of the validated modules are presented in Table 2.

Table 2. Eligibility Criteria for E-Module Based on Problem Based Learning

Score	Criteria
81-100	Very Good
61-80	Good
41-60	Enough
21-40	Not Good
0-20	not very good

(Arikunto, 2013)

The effectiveness of the problem-based learning-based E-module developed in this study was analyzed using the N-gain score based on the results of the operational field test phase. The formula for finding the N-gain score according to Hake (Zulaichah, et al., 2021) is as follows:

$$\text{N gain} = \frac{S\ post - S\ pre}{S\ maks - S\ pre} \text{ x } 100 \ldots\ldots\ldots\ldots (1)$$

A developed module can be categorized as effective if it has a high N-gain score. The interpretation criteria according to Hake (Zulaichah, et al., 2021) are seen in Table 3.

Table 3. Criteria for Interpretation of N-gain Score

Range	Category
$g \geq 0.7$	High
$0.3 \leq g < 0.7$	Medium
$g < 0.3$	Low

Result and Discussion

Electronic modules or commonly known as e-modules developed in this study refer to Basic Competency 3.6 which explains various additives in food and beverages consumed daily, as well as their impact on human health, as well as Basic Competence 4.6 which presents data, information, proposes a problem-solving idea in order to avoid the abuse of additives in food and beverages as well as narcotics and psychotropic addictive substances. Where the material is very important to motivate students to stay away from prohibited substances such as narcotics and psychotropic substances. This e-module based on problem-based learning on additives and addictive substances is arranged into three learning activities, one learning activity is counted as one meeting. Learning activities in the developed E-module include 1) coloring additives, 2) preservative additives, 3) addictive substances and their prevention efforts.

The characteristics of the developed E-module is that the learning activities contained in this E-module are arranged according to the syntax of the problem-based learning model or commonly referred to as problem-based learning according to Arends, including: problem orientation, class organization, group investigation, development and presentation of the results of the investigation, as well as analysis and evaluation of problem solving that has been presented (Ashari & Salwah, 2017). Each syntax in this E-module also includes activities to empower students' ability to think critically according to the indicators of critical thinking skills which include: 1) elementary classification, which is the ability of students to give simple explanations, 2) basic support, is the ability of students to build basic skills. , 3) inference, namely the ability of students to draw conclusions on a concept, 4) advanced clarification is the ability of students to provide further explanations, and 5) strategy and tactics is the ability of students to arrange a strategy or tactic to solve a problem. The relationship between problem-based learning-based e-modules in training students' critical thinking skills is presented in Table 4.

Table 4. The Relationship of Problem Based Learning-Based E-modules with Students' Critical Thinking Ability

Syntax Problem-Based Learning	The description of Learning Process	Critical Thinking Ability
Problem Orientation	Students are presented with problems related to real-world issues in the form of pictures	Elementary Clasification
Class Organizing	Students make questions based on the problems presented in the form of pictures Make answers to questions that have been made	Basic Support Advanced Clarification
Group Investigation	Doing practical activities	Elementary Clasification Basic Support Inference Advanced Clarification
Development and Presentation of Work	Submit test results	Basic Support Advanced Clarification
Problem Solving Analysis and Evaluation	Knowing the solution to the problem presented	Elementary Clasification Strategy and tactics

In problem orientation activities, students are presented with a real problem that occurs in the surrounding environment to be observed and studied by students to practice elementary classification indicators that analyze a reality. After the students observe the picture, in-class organizing activities, students make several questions as well as answers related to the problems in the picture so that they practice the Basic Support and Advanced Clarification indicators. In group investigation activities, students conduct experiments and then proceed with discussion activities with their group friends to answer questions and also draw conclusions, these activities can practice elementary classification, basic support, inference, and advanced clarification indicators. After conducting experiments and drawing conclusions, students will present the results of their work in front of the class and other groups to provide responses, then draw conclusions and also solutions to the problems presented. Students' ability to think critically can be honed through learning activities like this.

E-learning modules based on problem-based learning on additives and addictive substances have been developed according to the characteristics of the problem-based learning model. Furthermore, validation is carried out by experts to determine whether the developed E-module is feasible or not to be used in learning activities. The validation carried out includes expert validators with media, materials, language, and learning experts. The validation results are presented in Table 5.

Table 5. Results of E-module Validation Based on Problem Based Learning

Validator	Score (%)	Criteria
Media Expert	100	Very feasible
	100	Very feasible
Material Expert	80	feasible
	90	Very feasible
Linguist	100	Very feasible
	82	Very feasible
Learning Expert	100	Very feasible
	91	Very feasible

Based on the results of the validation of media experts, linguists, material experts, and learning experts, the E-module based on problem-based learning on additives and addictive substances is declared very feasible to be used in the process of learning activities because the percentage of scores obtained in each field is more than 75%. The results of the average overall score given by the validators are 92% which is included in the criteria that are very feasible to be used in learning activities.

The feasibility of the developed media is indicated by the ease of access, the attractiveness of the E-module design, informative content, good layout preparation, as well as animated pictures and videos that attract students' attention so they don't feel bored when learning activities using E-learning module. The feasibility of the material contained in the E-module is indicated by the complete material for the learning process on additive and addictive substances and is arranged in a coherent manner from learning activities 1 to learning activities 3. The feasibility of the language used in the E-modules is shown that the language which is used in accordance with the intellectual development of the students, the preparation of communicative, persuasive, and dialogical sentences so as to attract the attention of students to be more enthusiastic in learning but still in accordance with the Enhanced Spelling, in addition, if there are some words that sound foreign, the students You can find it in the glossary that is already available in the E-modules. The feasibility of learning in the E-modules includes the presentation of learning that is packaged for student-focused learning, active learning and has also been oriented to train students' critical thinking skills through problem-based learning models.

After the E-modules has been validated by experts, then some improvements are made according to the direction of the experts. After going through the repair process, the module is ready to be used for the next stage, namely the limited trial stage. The limited trial was tested on 31 students of class VIII, this limited trial aimed to determine the readability of the developed E-modules. Limited trials that have been carried out in the field got the results of 86.7%, the score indicates that the E-modules based on Problem Based Learning on additives and addictive substances is very good and can be used to the next stage, namely the field operational test stage.

The effectiveness of E-modules based on problem-based learning on additives and addictive substances to improve students' critical thinking skills can be known through operational field trials. To determine the effectiveness of this E-modules, a one group pretest-posttest design was used. Before starting learning using the E-module, the students were given a pre-test first to find out how far the students' initial abilities were with additive and addictive substances. After doing the pretest, the students carry out each step of the learning activities that are already contained in the E-modules, then after being treated using the E-modules, the students are given a final test or posttest to find out whether the E-modules can successfully improve students' understanding of the material additives and addictive substances. The

tabulation of the students' pretest and posttest scores is presented in Figure 1.

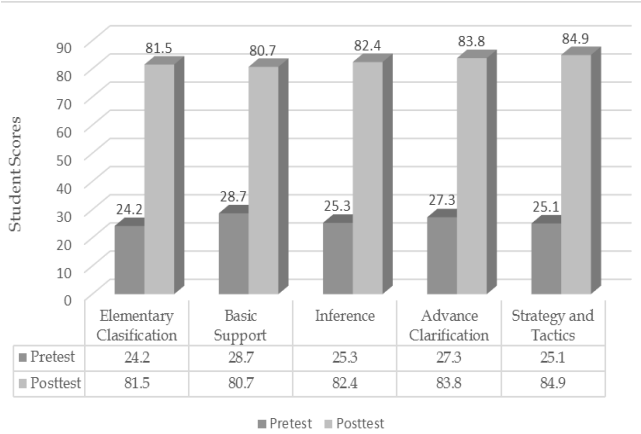

Figure 1. Value of Pretest - Posttest of Students' Critical Thinking Ability

Based on the picture above, it can be observed that the pretest score is lower than the posttest score on all critical thinking indicators including elementary classification, basic support, inference, advance clarification, and strategy and tactics. This shows that students' ability to think critically has increased after being treated with problem-based learning-based E-modules. The values from the pretest and posttest are then used to calculate the N-gain score which serves to determine the effectiveness of the E-module based on problem-based learning on additives and addictive substances to improve students' critical thinking skills. The results of the N-gain scores are presented in Table 6.

Table 6. N-gain Score Results of Critical Thinking Ability

Indicator	N- gain Score	Criteria
Elementary Clasification	0.75	High
Basic Support	0.72	High
Inference	0.76	High
Advance Clarification	0.78	High
Strategy and Tactics	0.80	High

Based on the calculation of the results of the N-gain students' ability to think critically, it was obtained an average of 0.76 which was included in the high category. In accordance with the results of the N-gain calculation obtained, it can be concluded that learning using E-modules based on problem-based learning on additives and addictive substances is effective in improving students' ability to think critically. Based on Table 6. it can be observed that the highest N-gain score is the last indicator, namely strategy and tactics, while the lowest N-gain score is basic support. The electronic module that has been developed can be seen in Figures 2 to 5.

Figure 2. E-Module Electronic Homepage

Figure 3. Student Learning Activity Pages in E-Modules

Figure 4. Description of Learning Materials in E-Modules

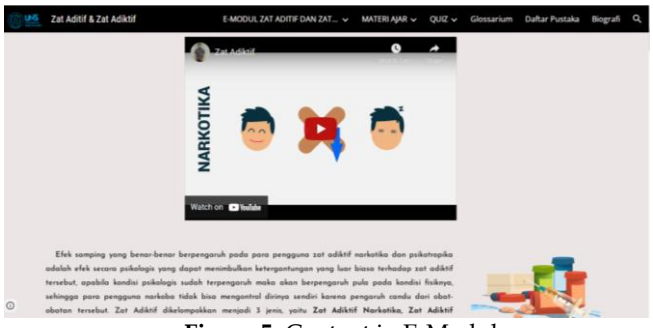

Figure 5. Content in E-Modules

The main activity in problem-based learning is the provision of problems that are required to be solved. When solving a problem, students are familiarized with discussion activities with their group of friends. Learning carried out in groups and also discussing with friends can stimulate students to exchange ideas, ask questions, and find new knowledge, this really supports the improvement of students' critical thinking skills. At the time of

problem-based learning, the teacher serves as a facilitator who monitors student performance and also directs if students experience errors or difficulties (Zulaichah, et al., 2021). Thus, the application of science modules based on problems in science material, especially additives and addictive substances can improve students' ability to think critically. In critical thinking learning activities, students can be invited to learn from different perspectives, especially regarding the impact of science, very rapid technological advances, and also problems that occur in the real world (Mapeala & Siew, 2015).

Conclusion

The development of electronic modules based on problem-based learning on additives and addictive substances can improve students' ability to think critically. Based on the results of expert validation, it was concluded that the E-module developed was very feasible to be used to support teaching and learning activities seen from the average validation result was 92% including the very feasible category. Followed by the results of the operational field trials showing that the developed E-module is effective for improving students' critical thinking skills, the average N-gain score of 0.76 is in the high category.

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