Development of mathematics e-module with STEM-collaborative project based learning to improve mathematical literacy ability of vocational high school students

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Abstract - The research conducted was a research on media development in the form of electronic module in mathematics learning using a STEM-Collaborative Project Based Learning model which is believed to improve the mathematical literacy skills of vocational high school students. The test subjects in this study were students of Vocational High School 1 Panji Situbondo where the data analysis technique used in this development research was descriptive analysis techniques. The quantitative data that had been obtained from the Likert scale measurement were converted based on the weighted score that has been determined. This data is quantitative data which were further analyzed by descriptive statistics. The scores obtained from the questionnaire were then converted so that the eligibility percentage was known and the conclusion that the e-module developed was valid, practical and efficient. The benefit that could be obtained from this research was the contribution of thoughts to improve the quality of education, especially in mathematics learning by presenting new insights regarding the preparation of learning tools in the form of e-modules as an alternative to learning media for mathematics to improve the quality of the learning process.

1. Introduction
A developed country cannot be separated from the quality of human resources as the main constituent in it. Quality human resources are the major factors in the development of the current era of globalization. Human development itself is defined as a process of expanding people's choices (a process of enlarging people's choices) [1]. In 2019, Indonesia's Human Development Index reached 71.92. This figure increased by 0.53 points or grown by 0.74 percent compared to 2018. Efforts that can be made to improve the quality of human resources in Indonesia in the future will be correlated with the efforts of the education world to create a future golden
generation by meeting the demands of student abilities based on K-21, especially in mathematics, is not just the ability to count but the ability to reason, think logically and critically in solving every problem in life. One of the demands is the ability of mathematical literacy as stated in the 2012 PISA assessment framework draft, namely Mathematical literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain, and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens [2][3][4].

It is believed that mathematical literacy skills were increased in line with a positive increase in students' cognitive as a result of learning conditioning that stimulates students' thinking processes to be able to comprehensively respond to a problem in their life. The STEM-CPBL model, namely the Project Based Learning model equipped with collaborative learning studies, will be believed to increase the effectiveness of learning mathematics in comparison with the classical method, proven to also reduce mathematics anxiety in students significantly and help increase seeking behavior and reduce its avoidance components [5][6][7][8]. Other studies have also investigated how project-based learning that combines multi-disciplinary science, technology, engineering, and mathematics (STEM) affects students with high needs in the United States (US) in terms of their academic performance. Data is a math test from 2008 to 2010 of the Texas Assessment of Knowledge and Skills. PjBL's STEM instruction positively affects student's achievement. The findings of this study imply that the curriculum integrating STEM PjBL can help students have language and cultural differences to improve communication and collaboration skills in the classroom [3][8][9][10][11][12][13][14][15][16].

Based on a preliminary study conducted on 9 mathematics teachers at Vocational High School 1 Panji Situbondo, it was found that the majority of teachers still used teaching materials in the form of textbooks from publishers and classical learning models so that the tendency that occurs is that teachers were the most dominant learning source. This can also be seen in the theoretical learning process, the lack of student interaction, the learning process was determined by the teacher so that it gives a boring impression and does not hone students' mathematical literacy skills.

Based on the results of interviews conducted with students, it was known that students were not accustomed to active and independent learning using modules and still conditioned the teacher as the only source of knowledge. The main cause of this condition is the lack of teacher facilitation in the learning process which can lead students to thinking patterns of the ability to apply mathematics in everyday problems so that they can be sure that their mathematical literacy skills are also very low. Electronic modules in mathematics learning are expected to be able to help students achieve learning objectives and are expected to carry out analysis in solving contextual problems [17]. The e-module form that will be developed is the STEM-CPBL e-module which can be used as an independent learning guide equipped with a cross-disciplinary approach, namely, Science, Technology, Engineering and Mathematics. Therefore, based on this description, it is deemed necessary to conduct a study entitled "Development of Mathematics e-Module with STEM-CPBL to Improve Mathematical Literacy Ability in Students".

2. Research Methods
The development model used follows the 4-D Thiagarajan model. The 4-D development model consists of 4 stages, namely Define, Design, Develop, and Disseminate [18] shown in Figure 1 below.

![Figure 1. Steps to Develop e-Module Applications with the 4-D Model](image-url)
2.1 The Define Stage

At this initial stage, curriculum analysis is carried out by examining basic competencies, formulation of learning objectives as outlined in the making of a lesson plan, study of data types and data sources or analysis results containing studies of learning difficulties, and potential resources. Initial data collection was carried out through interviews with fellow mathematics subject teachers related to curriculum analysis, learning media and topics or materials that often found problems in developing mathematical literacy skills in students. Based on the results of the preliminary data, it was obtained several things related to the use of instructional media that were not yet effective and had not accommodated the use of technology in learning.

| No | Type of Data | Data Sources / Analysis Results |
|----|--------------|---------------------------------|
| 1  | Study of learning difficulties topic Linear Program. | • Reference to national and international research results.  
• Interviews with mathematics subject teachers. |
| 2  | Potential resources (teachers, students and IT facilities & infrastructure) | Field observation results |
| 3  | Study of Basic Competency content and Learning Implementation Plan | • Permandikbud nomor 21 tahun 2016  
• Mathematics Subject Teacher Deliberation Vocational High School 1 Panji Situbondo Banner |
| 4  | Study of learning media used. | • The learning media used are not varied.  
• Not yet accommodating the use of technology.  
• Has not stimulated mathematical literacy skills |

2.2 The Design Stage

After obtaining an initial description, then designing the learning media were used as an electronic module or often called an e-Module. The next design stage is the selection of the format, namely Kvisoft Flipbook Maker, which can later be read on Personal Computer and Android. After the format selection is complete, the next step is to prepare a digital script in the form of a word file which will later be converted into a Pdf file which is then transferred to the Kvisoft Flipbook Maker application in the form of an exe file.

| Program Files | Contents | Information |
|---------------|----------|-------------|
| Format Selection | The format used is based on android and or can be opened on a PC (exe file) | Kvisoft Flipbook Maker is a software used to convert text manuscripts into digital scripts. |

Digital Script creation stage
Design Early

This stage includes the initial creation of the e-Module from several files, namely:
- Word
- Pdf
- Exe

Completion of the e-module application can be revised and adjusted after the trial process.

2.3 The Development Stage
This stage focuses more on filling in content in accordance with the systematics of a module which consists of the beginning, introduction, learning, training and evaluation as well as a bibliography. After completing the content filling, then a limited trial was carried out in schools and the Teacher’s Mathematics Community.

Table 3. e-Module Development

| COVER | II. LEARNING |
|-------|--------------|
| Module title | Learning |
| Subject | Activities |
| Name | Objectives |
| Topic / Class Learning Material | Job Summary |
| Author of the Table of Contents | Material |
| Glossary | Description |

Self-Assessment Exercises

I. Introduction
KD and GPA
Brief description of the material, rationale, and relevance
Precondition
Instructions for using the e-Module

II. LEARNING

Activities
Objectives
Job Summary
Material
Description
Self-Assessment Exercises

III. REFERENCES

EVALUATION

ATTACHMENT

F-Module Development Trial
1. Limited Trial
2. Description of Student and Teacher Activities in Learning Using e-Modules
3. Student Responses to Learning Using e-Modules

2.4 The Disseminate Stage
This activity is the result of the 3 stages above, namely in the form of use in learning and seminars at school.

Table 4. E-Module deployment

| Activities | Target | Implementation Date |
|------------|--------|---------------------|
| 1. Wider use of e-Modules in learning | Class X MM | September - October 2020 |

2. Seminar | All residents of SMKN 1 Panji | October 2020 |

3. Results and Discussion
3.1 Development of e-Module Mathematics Based on STEM-Collaborative Project Based Learning.

For the quality and validity of the media being developed, expert validation will then be carried out. Validation was carried out by three experts, namely mathematics education experts, media experts
(mathematics and educational technology lecturers) and practicing experts (mathematics subject teachers). Expert validation scores of 4 and 5 (on a scale of 5) are in very good categories. The list of the frequency distribution of the validators' assessment is presented in Table 5 below.

Table 5. Frequency Distribution of Expert Validation

| Criteria       | Frequency | %       |
|----------------|-----------|---------|
| Very           | 40        | 74.07   |
| Well           | 14        | 25.93   |
| Well Enough    | 0         | 0.00    |
| Less           | 0         | 0.00    |
| Very Less      | 0         | 0.00    |
| Amount         | 54        | 100.00  |

(taken from 20 statement items)

Based on the data in Table 5, it can be seen that based on the predetermined assessment indicators, experts say that the eModul application is in the very good category (74.08%) and good category (25.93%). In general, the comments of the experts state that the e-Module application is interesting and can be used as a medium for learning mathematics on the topic of the Linear Program. Some of the findings and suggestions for improvement include: e-Module instructions should be made more detailed so that they are clearer to users, add general information about e-Module, the application does not display interactive questions.

3.2 Mathematical Literacy Ability of Students through Descriptions of Student and Teacher Activities in Learning Using e-Module

After the e-module is validated by experts and declared worthy of a range of good or very good assessment results, then the e-module is also assessed by students to provide a general display assessment from the point of view of a user. The assessment was carried out by giving a questionnaire containing several statements about the e-module. The trial was carried out in small groups, namely to 36 students of class X.

In general, students' responses to e-Modules can be used as an alternative to learning media for Linear Program material in a fun way, as many as 76.67% of students strongly agree that the initial appearance of e-modules is interesting so they are curious to try it immediately, and 10% agree. As many as 90% of students stated strongly agree and e-Module can increase motivation to learn mathematics, 96.67% respondents answered strongly agree.

3.3 Student’s Responses to Mathematics Learning Using e-Modules

To find out students’ responses to learning, students were given a questionnaire after learning takes place. The statements in the questionnaire cover things related to learning using e-module that have been done.

In general, students’ responses to learning mathematics using e-module make students interested in learning in class by 93.33% (almost all) and 83.33% (almost all) students were not lazy to participate in learning activities using e-module and most (63.33%) students were active and enthusiastic about learning using e-module.

3.4 The Importance and Novelty of Research That Has Been Implemented.

In its development, the use of e-module at Vocational High School 1 Panji Situbondo has provided creative space and character development for students and teachers, including:

a. Fellow teachers want to make digital scripts for learning purposes.
b. The use of android as a learning medium can be implemented outside of school.
c. The pattern of students’ independence in running the e-module can be seen from several reports of students trying to run quizzes several times to get the maximum score (100).
d. The various inputs on e-module motivate the developer to create new versions and other materials.
e. Motivating developers to make books on digital scripts (making e-module).
4. Conclusions and Suggestions

The conclusions obtained from this research are:

1. Based on the results of the validation test by media experts, material experts, and practicing experts, it is concluded that 74.07% of e-module were declared "Very Good" and 25.93% were declared "Good".

2. Based on the results of student responses, learning using e-module as much as 90% of students stated strongly agree and e-module can increase motivation to learn mathematics, 96.67% respondents answered strongly agree.

3. Based on the results of student responses, learning using e-module implements digital literacy skills for students through descriptions of student and teacher activities. Learning using e-Modules creates interest in learning in class by 93.33% (almost entirely) and 83.33% (almost all) students were not lazy to participate in learning activities using e-module and most (63.33%) participants students were active and enthusiastic about learning using e-Module.

During the research and development process that had been passed through the 4-D Model procedure, several weaknesses and strengths were found, so for future improvements some suggestions are made as follows:

1. e-module can be optimized as worksheets that can be accessed online by students.
2. After the e-module can be optimized, test the effectiveness of its use.

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