Development of an E-Module on Derivative Applications for Vocational High School Students

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ABSTRACT

The Covid-19 pandemic has impacted the learning process, including the learning of mathematics. This situation has caused students and teachers not always be able to interact directly, which can result in learning loss. Therefore, efforts are needed to develop learning media that allow students to learn independently and actively. This study aims to develop a Mathematics E-Module that is different from most of the modules available, where students can interact with the E-Module. The E-Module was developed using the modified Plomp development model. The results of the study show that the developed E-Module meets the level of validity with a category of very valid, as well as the practicality of the E-Module. Other findings during the testing process showed that this E-Module can increase students' active and independent engagement in understanding the concept of derivative relationships with increasing functions, decreasing functions, and maximum/minimum values. Therefore, E-Module is recommended because it is very suitable for use in learning both online and offline. E-Module with GeoGebra applet can improve vocational school students' ability to discover concepts independently.

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A. INTRODUCTION

Nowadays, providing high quality learning using technology has become more important (Konstantinidou & Scherer, 2022). The presence of technology has become essential in efforts to avoid the learning loss experienced by student Açıkgül & Şad (2021); Asadullah & Bhattacharjee (2022); De' et al. (2020); Engzell et al. (2020) as a result of the COVID-19 pandemic, where the pandemic status has not yet been lifted by the government. In addressing learning loss, the government has been encouraging schools to utilize technology in the learning process.

The integration of technology into mathematics education brings about changes in the teaching of mathematics (Prodromou & Lavicza, 2017). Both teachers and students are important in having access to technology that supports and advances mathematical understanding, reasoning, problem-solving, and communication (NCTM, 2015). Effective teachers optimize the potential of technology to develop understanding, stimulate interest, and enhance students' mathematical abilities. When teachers use technology strategically, they can provide greater access to mathematics for all students. Research results show that the use of technology supports mathematics learning (Adelabu & Alex, 2022). Therefore, the efforts of

teachers play a very important role in using technology in the process of mathematics learning (Buentello-Montoya et al., 2021; Chirinda et al., 2021).

Learning during the COVID-19 pandemic has led to the transformation of learning materials that were previously delivered directly by teachers into electronic materials. This has occurred in almost all schools. According (De' et al., 2020),since the beginning of the pandemic, both schools and universities around the world have shifted their classes to video conferencing platforms such as Zoom and Google Meet. Digital transformation technologies such as Artificial Intelligence, Machine Learning, or Internet-of-Things, are mostly adopted to facilitate learning(Haleem et al., 2022; UNESCO, 2020). Digital technologies are a potent tool that can enhance education in a number of ways, including by making it simpler for teachers to create educational materials (Carvalho et al., 2022; Varea et al., 2022).

In Indonesia, learning with utilizing technology has generally been conducted. Examples of technology utilization include the use of e-Modules in .pdf format , presentations in .ppt format, worksheets in.docx format, and the use of LMS such as Moodle, Google classroom, or Gafe (Rahman, 2022; Siti Nurjannah Iswandari, 2020; Ula et al., 2021). The similarity of most e-Modules currently available is one-way or static, meaning that students obtain information or knowledge from the e-Module by simply reading or watching the teacher demonstrate the application.

The use of applications in mathematics learning has been widely used, such as GeoGebra, Cabri, or Desmos applications (Gulli, 2021; Tesfamicael, 2022). Although they have been used, these applications are only used as tools for teachers to help students understand the material. Students do not directly interact with the application(Prodromou & Lavicza, 2017). This situation causes students to be passive(Journal et al., 2020). Students are less involved during the learning process because they are only receivers of information from the teacher without actively being involved in obtaining new information (Shubhendu, 2017). To support active learning using technology, it is necessary to provide learning facilities, including e-Modules that involve applications.

The development of e-Modules in learning is very necessary (Wulandari et al., 2021), including in mathematics learning. Various e-Modules have been developed by researchers. Research (Seftiana Aziza & Supriatna, 2021) used e-Modules by printing lesson material in electronic form, so that students can access the material using the internet and can be saved on a CD-ROM. Research SAYGILI & ÇETİN (2021); Shaame et al. (2020); Sukarman et al. (2021) developed mathematics e-Modules using Learning Management Systems (LMS) on geometry for junior high school students, while Kartiko & Mampouw (2021) developed e-Modules based on android applications on inverse proportion concept. The results of the research show that the development of e-Modules is very necessary in supporting learning, especially mathematics.

Based on the research results that have been conducted, there have not been many e-Modules developed in such a way that students can actively interact with e-Modules equipped with applications. Therefore, in this research, a learning media in the form of mathematics e-Modules based on guided discovery was developed, enabling students to learn interactively so that they can actively learn independently. GeoGebra is very helpful for students and teachers in the process of mathematics learning and has many advantages, conceptualizing and utilizing mathematics dynamically and are often used as a learning and teaching tool in schools (Dahal

et al., 2022; Ziatdinov & Valles, 2022). GeoGebra is an open-source (free) mathematics software program that is easy to use, combining geometry, algebra, and calculus features (Birgin & Acar, 2022). Points, line segments, polygons, straight lines, conic sections, and functions are some of the artifacts in GeoGebra. These artifacts allow for dynamic construction changes. GeoGebra helps visualize mathematical concepts, making it easier to build relationships between graphical representation and calculus and algebra (Gökçe & Güner, 2022). Also, Praveen & Leong (2013) conducted quasi experimental study was to evaluate students understanding in learning circle using GeoGebra. The outcome showed that experimental group students fared better than control group. Additionally, a survey tool was employed to find out how the students felt about using GeoGebra. Analysis of the survey results revealed that utilizing GeoGebra to learn about circles was generally viewed favorably.

The development of this e-Module was carried out on the topic of derivative applications. The derivative application topic includes understanding the relationship between derivatives and increasing and decreasing functions, as well as the maximum and minimum values of a function. This material is very important for students to understand (Hamid et al., 2019; Illanes et al., 2022). There has not been an interactive learning media on the topic of derivative applications yet. With the development of this guided discovery-based e-Module, students can actively interact with the learning media. The learning experience gained from discovering on their own is expected to be more meaningful for students to learn the next material.

B. METHODS

This study is a development research. The product developed is an e-Module with GeoGebra applets integrated into it. The mathematics material used in this study is derivative applications for grade 12 vocational high school students. The development model used in this study is a modified Plomp research model. The stages of research according to Plomp (Plomp & Nieveen, 2013) are: (1) Preliminary research; (2) Prototyping phase; and (3) Assessment phase. The research procedure in this study is illustrated in Figure 1.
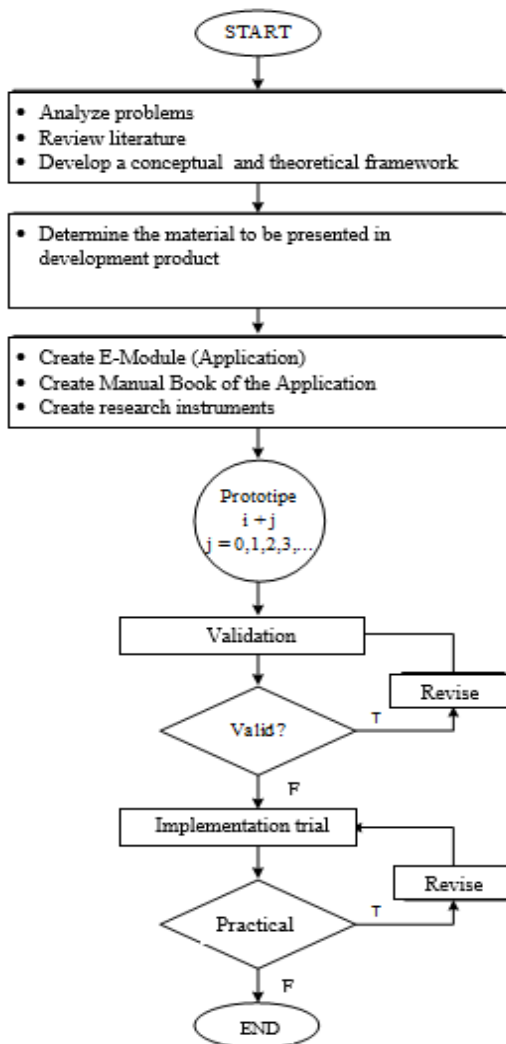
Figure 1. Procedure of Research

The trial was conducted at the partner school, which is Telkom Vocational High School in Malang. The research subjects in this study include: (1) media and material expert validators, (2) teaching staff, and (3) 40 students from class XI at Telkom Vocational High School in Malang. The data sources were obtained directly from the results of expert validation sheets by validators, questionnaire responses by students and teachers involved, as well as observations made by the researcher during the trial process. The data collection instruments used in this study were: (1) product validation sheets, (2) teacher and student response questionnaires for practicality testing, and (3) observation sheets. The average formula used to determine the validity and practicality of the product is as follows:

$$I_i = \frac{\sum_{j=1}^{n} V_{ji}}{n} \tag{1}$$

Where I_i The average value of validation results from all validators/respondents for each indicator/component; V_{ji} : The validator's j-th value data for the i-th indicator/component; n : The number of validators/respondents

Meanwhile, the percentage of validity for each indicator (Pi) and the percentage of assessment for all component/indicator aspects (Ri) are determined using the following formulas.

$$P_i = \frac{I_i}{k} \times 100\% \tag{2}$$

Where P_i: Percentage of validation results for each indicator/component; I_i : Average value of validation results from all validators for each indicator/component; k: Highest scale

The percentage of assessment for each aspect is determined by the following formula:

$$R_i = \frac{\sum_{i=1}^{n} P_i}{m} \tag{3}$$

Where R_i : Percentage of overall validation results for all indicators/components; P_i : Percentage of validation results for each indicator/component; m : Number of indicators/components.

To facilitate the determination of the level of validity and practicality of the developed product, a validation/practicality testing result criteria scale is used. The criteria are presented in Table 1.

Table 1. Validation/practicality testing result criteria scale

Percentage of average validation/practically score	Valid Criteria	Note
$85 \leq P \leq 100$	Very valid /practical	No Revision
$70 \leq P < 85$	Valid / practical	No Revision
$55 \leq P < 70$	Valid/practical enough	Revision
$40 \leq P < 55$	Valid / practical less	Revision
$0 \leq P < 40$	No valid / practical	Revision

C. RESULT AND DISCUSSION
1. Result

In accordance with the research objectives of developing and describing the process of developing the E-Module and the stages of development in the research method, the research results are presented as follows.

a. Mathematics E-Module Prototype

The E-Module developed is in epub format, which makes it highly suitable for online, offline, or hybrid learning. The E-Module contains several components, such as motivation and apperception videos that can be viewed directly in the E-Module; it also contains a GeoGebra applet, which is the most important component of the E-Module, and student worksheets, as well as quiz exercises.

The most important component that sets it apart from other E-Modules is the GeoGebra applet, which is designed in such a way that students can actively engage with it. The

applet presents instructions based on guided discovery, allowing students to construct their own understanding of derivative applications. Students can interact actively with the module, enabling them to infer the relationship between derivatives and rising and falling functions, the relationship between derivatives and the maximum and minimum values of functions, based on their learning experience. This interactive E-Module supports students in meaningfully learning derivative application material.

The E-Module mechanism consists of preparation and use stages. The mechanism is presented in Figure 2. In the preparation stage, students install an epub reader and download the E-Module, then add the E-Module to the installed epub reader. After successfully adding the E-Module, it is ready to be used in learning. First, students are asked to read the introduction section, which contains information about the E-Module's identity, basic competencies, a brief description of the material, module usage instructions, and learning materials, as shown in Figure 2.
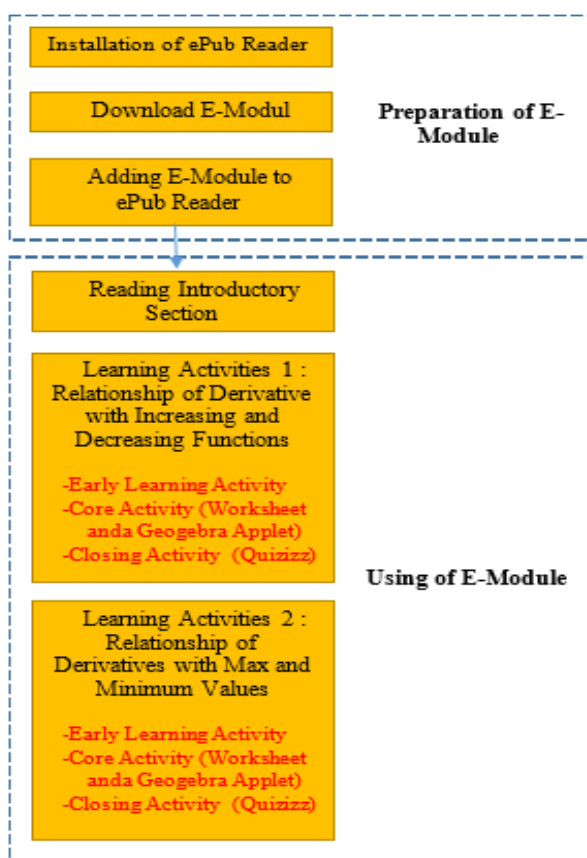

Figure 2. E-Module Mechanism

Then, students move on to the first learning activity section. Learning activity 1 consists of: (1) learning objectives; (2) competency achievement indicators; (3) initial learning activities; (4) core learning activities; and (5) final learning activities. In the initial learning activity, students are asked to watch apperception and motivation videos. The apperception video aims to remind students of the meaning of rising and falling functions, while the motivation video aims to show the use of material in daily activities, making students interested in learning the material.

Next, in the core learning activity section, students are asked to download the Student Worksheet, which contains instructions to guide students in discovering the concept of the relationship between derivatives, increasing and decreasing functions. On the worksheet, students are asked to visit the GeoGebra Applet link, which is used by students in exploratory activities. The presence of the GeoGebra Applet in this E-Module is an attractive feature of the E-Module, as indicated by the results of interviews with two randomly selected students who stated that they were happy because they had never used GeoGebra Applet in their previous learning experiences. Finally, at the end of the lesson, students are asked to complete the Quiz exercise.

As mentioned earlier, the developed E-Module has significant differences from other E-Modules. The distinguishing feature is that this E-Module allows students to interact with it. The interaction refers to students interacting with the module using the GeoGebra Applet. First, students are asked to log in to the GeoGebra Applet. The login page is displayed in Figure 3.
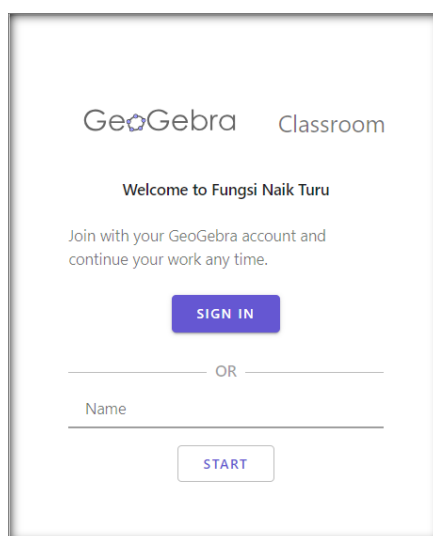

Figure 3. Pages of GeoGebra Login

After that, students are asked to input the function to find the derivative value, function graph, and derivative function graph in the input box. Then, students press enter, so that the derivative value, function graph, and derivative function graph will be displayed. For more details, it is shown in Figure 4.
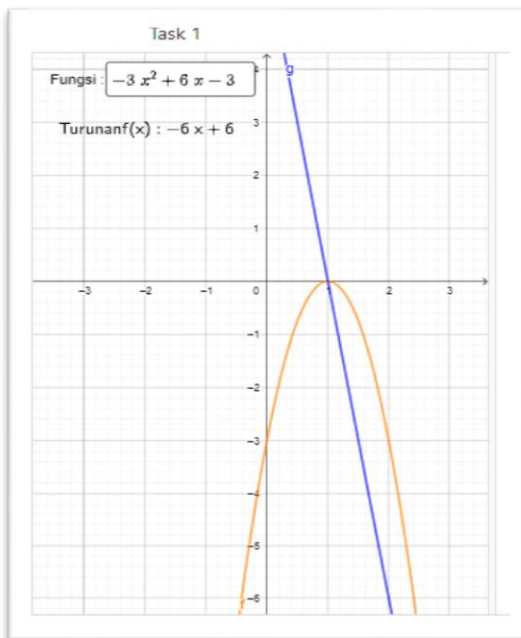
Figure 4. Input Function and Results

Then, students observe the graph of the function, in which intervals the function is increasing and in which intervals it is decreasing, and whether the value of its derivative is positive or negative. Then, students check their observations by filling out the form on the right side of the GeoGebra. If everything is correct, students move on to the stage of recording their observation results on the LKS. The function check form is shown in Figure 5.

Figure 5. Check of Function

b. Validation Test of Mathematics E-Module

The validation process begins by providing the E-Module, guidebook, and validation test sheet. The validation involves two validators, material and media validators. The following shows the results of material and media validation, as shown in Table 2 and Table 3.

Table 2. Material Validation Test Result

Aspect	Percentage
The suitability of content, language, and appearance	87,5%
Construction of Guided Discovery E-Module	89%

Table 3. Media Validation Test Result

Aspect	Percentage
The appearance of the E-Module catches attention.	75%
The text and letters in the E-Module are clear and readable.	
The font type used in the E-Module is appropriate.	100%
The colour selection for the media and text is compatible to support the material to be easily readable.	75%
The simplicity of the layout of the application makes the material easy to understand.	100%
Are the videos in the application appropriate for the intended purpose?	100%
The voice dubbing in the video explanation is audible and clear.	100%
The selection of images as supporting material for the video is appropriate.	100%
The E-Module can be run smoothly on a laptop.	75%

From the material validation results, an average validity percentage of two aspects was 88.2% for the E-Modul. For media validation, there are 7 aspects to be assessed as shown in Table 3. After calculating the average of 7 aspects, we get an average validity percentage of 90.625% was obtained. Based on Table 1, the E-Modul is considered very valid, because the percentage of average validation score are on interval [85,100), it means there is no revision for E-Modul and it can proceed to the next stage of being tested on a limited basis by vocational high school students.

c. Limited Trial of Mathematics E-Module

After the developed product was declared valid, we conducted a limited trial of the Mathematics E-Module with 40 students from Telkom Malang Vocational High School. The limited trial was conducted to observe the practicality of the developed E-Module. The E-Module trial was carried out by providing a manual book to the model teacher. Then, the model teacher used the E-Module in their teaching. The students started using the E-Module by installing Readium as an EPub Reader. After that, the students downloaded the E-Module from the link provided by the teacher. Then, they added the downloaded E-Module to Readium so that it was ready to use. The data obtained from the limited trial consists of quantitative data that came from the questionnaire responses of 40 students. The practicality test results showed a percentage of 81.25%, thus according to the practicality criteria table, in Table 1, for the developed E-Module, it is considered very practical and does not require any revisions.

2. Discussion

The developed module has not only been declared valid and practical but also has special characteristics. These characteristics are the reason for the practicality of the developed product. Here is a description of the characteristics of the E-Module. Firstly, the E-Module provides an opportunity for students to actively participate in learning. Student involvement is one of the determining factors in the learning process (Ginting, 2021). One indicator of student involvement in learning is when students actively participate in every task and activity given (Chapman, 2002). In this E-Module, student involvement is demonstrated when they are able to follow the instructions given in the E-Module effectively.

Secondly, the developed E-Module has a main component in the form of the GeoGebra Applet. The presence of the GeoGebra Applet, which students have never encountered before, is considered interesting. Students become motivated when operating the GeoGebra Applet. This is in line with the research conducted which found that adding technology in classroom learning can increase student motivation (Aguadera et al., 2020). Thirdly, the instructions contained in the E-Module are structured based on guided discovery, making students able to discover concepts on their own about the relationship between derivatives with increasing and decreasing functions, as well as the relationship between derivatives and maximum and minimum values. One learning method that encourages students to think constructively is guided discovery learning. Guided discovery learning is a learning method that allows students to discover things on their own, so that they can draw conclusions based on teacher guidance in the form of questions asked (Firman Amardani Saputra et al., 2022).

D. CONCLUSION AND SUGGESTIONS

Based on the analysis, the developed e-Module was considered valid and practical. The average validity percentage of the material validation was 88.2%, and the average validity percentage of the media validation was 91.67%. The practicality of the e-Module was 81.25%. Therefore, E-Module is recommended because it is very suitable for use in learning both online and offline. The advantages of this mathematics e-Module on the topic of derivative application are that it contains instructions that guide students in discovering concepts independently, such as the relationship between derivatives and increasing/decreasing functions, as well as maximum and minimum values of a function. In addition, this e-Module also has a GeoGebra applet which is an important component that motivates students to use it. This research has limitations, including the fact that the e-module is only used for the topic of limit usage and is only tested with vocational high school students. Therefore, future research can develop the e-module for mathematics as a whole and use it for high school or junior high school students. In addition, future researchers can examine the effectiveness of developing the e-module with GeoGebra applets as evidence of the benefits of such development.

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