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Development of Foundation Engineering E-Module in Building Engineering Education Study Program, State University of Jakarta

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Abstract

In the period of the fourth industrial revolution, technology plays an essential role in learning. Educators are working to improve the quality of learning by producing creative and exciting technology-based teaching materials that raise students' interest and ease of learning. One instance of technology being utilized in education is e-modules. The aim of this research is to develop e-module teaching materials for foundation engineering courses. Research and development model from Thiagarajan or 4D is used in this research. The four stages that were employed in this research are define, design, develop, and disseminate. This research sample consists of media expert validators, material expert validators and user evaluations. Validation findings from material specialists received an average evaluation percentage of 86%, while validation results from media experts obtained an average assessment percentage of 81%. This demonstrates that the development of e-module-based teaching materials for foundation engineering very suitable for use. Meanwhile, user evaluations on the creating of e-module-based foundation engineering teaching materials were deemed extremely acceptable for usage (average 89.3%). Based on the results of limited trials conducted on Building Engineering Education Students, it shows that the learning results of students have increased by 16.6% through a mean score of 70 on the pretest and 82 on the posttest.

Keywords: Teaching Materials, E-modules, Foundation Techniques.

1. Introduction

Education is the endeavor of human beings to cultivate and enhance their innate abilities and potential, both mental and physical, in alignment with the cultural and societal ideals that shape their community [1]. In the fourth industrial revolution age, technology is crucial to education [2]. The term "digital disruption" in education describes how technology is influencing traditional educational models and institutions, changes to the present paradigm are required to better suit the requirements of students and the times [3]. Currently, Indonesian education policy also promotes education at all levels, with a focus on leveraging advancements in digital technology [4]. This is a significant demand and challenge that has a number of potential solutions, such as the formation of students' moral principles, the preparedness of Human Resources (HR) to use Information and Communication Technologies (ICT), and the infrastructure and facilities for digital-based learning [5], [6].

The process of teaching and learning has benefited from technological improvements in education [7]. As a result, educators must improve the standard of instruction using the newest technologies [8]. The newest technology can be tried to be included into the teaching and learning process by educators. Teachers should be able to use technology to produce more imaginative and captivating lesson plans

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that will grab students' interest and help them learn [9]. One example of how technology is being utilized in education is the creation of innovative and useful teaching tools that are available to students at all times and from any location [10]. Furthermore, it is now challenging for educational institutions to provide instructional resources that complement textbooks. Thus, the creation of instructional materials in the form of e-modules is required [11]. E-modules can be used via electronic devices such as computers, laptops, tablets, even smartphones [12]. This teaching material is considered practical because it summarizes material, practice questions and systematic learning instructions into one [13]. The final objective of the learning activities in the e-modules is to let students know what they must grasp or comprehend in order to meet the predetermined learning goals. Students can study individually and analyze their own understanding levels using e-modules [14]. The e-module will present interactive media displays such as animation, video, audio and other features that can be played back as desired. Students need e-modules as an alternative digital-based tool in the current learning system which is expected to help independent learning, as well as being easy to carry and understand. According to the findings of a needs analysis conducted by giving questionnaires to thirty-two students enrolled in the Building Engineering Education Study Program, Faculty of Engineering, State University of Jakarta (UNJ), thirty-one (96.9%) of the students said that e-modules for Foundation Engineering instruction needed to be developed. Previous research has been conducted on the development of e-modules in learning, particularly in the program study in Building Engineering Education at State University of Jakarta, and the results show that e-modules improve learning in courses such as engineering drawing [15], soil mechanics [16], and concrete structures II [17].

Based on observations the implementation of foundation engineering learning in the program study in Building Engineering Education at State University of Jakarta has so far been carried out face to face (offline) and indirectly (online). The presence of lecturers still dominates foundation engineering lectures. Through research into the development of e-module-based foundation engineering teaching materials, it is hoped that students can get used to independent learning and increase student literacy, especially in the realm of knowledge of building foundations. Based on the results of a needs analysis carried out by distributing questionnaires to 32 students of the Building Engineering Education Program Study, Faculty of Engineering, State University of Jakarta, 96.9% of students stated that there was a need to develop foundation engineering teaching materials in the form of e-modules for use in foundation engineering learning. This research is important to carry out to increase student independence and learning outcomes in foundation engineering courses as well as to facilitate more interactive and efficient learning by utilizing digital technology. The novelty in this research lies in the focus on developing a special e-module for the foundation engineering course, which has never been done before. This research presents innovation by providing digital learning resources that are different from other technical courses, with the aim of increasing learning effectiveness and adapting to modern needs in building engineering education.

2. Methods

The research was carried out from March to October 2023 at the Building Engineering Education Study Program, Faculty of Engineering, State University of Jakarta and aims to create foundation engineering e-modules as instructional materials which consist of four parts (learning activities), namely: (1) Part I, which discusses foundation classification, comprehending, and choosing a type of foundation; (2) Part II, which discusses soil investigation; (3) Part III, which includes types of foundation failure, bearing capacity theory, bearing capacity from field tests, and soil settlement calculations; and (4) Part IV, which discusses separate footing foundations, longitudinal footing foundations, combined footing foundations, cantilever footing foundations, and raft foundations. To create a new product, the research use the 4D (Four-D) research model and the Research and Development (R&D) approach which consists of four main stages, namely: (1) Define; (2) Design; (3) Development; (4) Disseminate.

In the first stage, (define) researchers carry out a development needs analysis. Needs analysis activities are carried out by observing and observing during the teaching process, including: Front-end analysis, learner analysis and task analysis. In the second stage, (design) the researcher carries out the planning stage in developing the module, this stage includes: Identifying learning medium that is appropriate/relevant to the properties of the content, choosing a format for designing the content of

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teaching materials, choosing learning strategies and learning resources as well as initial designs for materials teaching that is developed and adapted to previous designs, such student learning results tests, student worksheets, and learning implementation plans. In the third stage, (develop) researchers prepare learning products taken from various learning sources of foundation material, The product outcomes are then confirmed by material specialists and media experts via assessment sheets in the form of questionnaires, then the learning products are revised according to the validation outcomes (corrections and suggestions). from material experts and media experts, then tested on a limited basis. The results of validation and testing are then calculated in percentages to determine the validity of the instrument. The following data calculation formula is used.

$$\text{Average Score (\%)} = \frac{\text{Total score obtained}}{\text{Maximum Score}} \text{ x } 100 \quad (1)$$

To ascertain the e-module eligibility category, the average score will be modified in accordance with the score interpretation criteria Table 1.

Table 1. Score Interpretation Criteria [18]

Score (In Percent %)	Category
81 – 100	Highly Suitable
61 – 80	Suitable
41 – 60	Fairly Suitable
21 – 40	Less Suitable
0 – 20	Highly Unsuitable

Student learning outcomes are used to examine the cognitive element, namely how well the student understands the topic. To assess the efficacy category of the e-module for the foundation engineering course, the generated n-gain will be calibrated to the cognitive enhancement criteria scale. The following data calculation formula is used:

$$n\text{-}gain = \frac{Average\ posttest\ score - Average\ pretest\ score}{Maximum\ Score - Average\ pretest\ score} \quad (2)$$

Table 2 presents the criteria used to categorize cognitive improvement based on the n-gain score. These criteria classify the effectiveness of the e-module in enhancing students' cognitive understanding of the foundation engineering course into three levels: high if the n-gain score (g) is equal to or greater than 0.7, indicating a high level of cognitive improvement; medium if the n-gain score (g) is between 0.3 and 0.7, indicating a moderate level of cognitive improvement; and low if the n-gain score (g) is equal to or less than 0.3, indicating a low level of cognitive improvement. These categories help assess how effectively the e-module has improved students' understanding of the course material.

Table 2. Cognitive Improvement Criteria Scale [19]

Gain score	Effectiveness Category
$(g) \geq 0{,}7$	High
$0{,}3 \leq (g) \leq 0{,}7$	Medium
$(g) \leq 0{,}3$	Low

The fourth stage involves dissemination. This phase includes the implementation of the finalized e-module-based foundation engineering teaching materials in foundation engineering lectures. Additionally, these products are distributed through the Foundation Engineering course's Learning Management System. The module development procedure is described in Figure 1.

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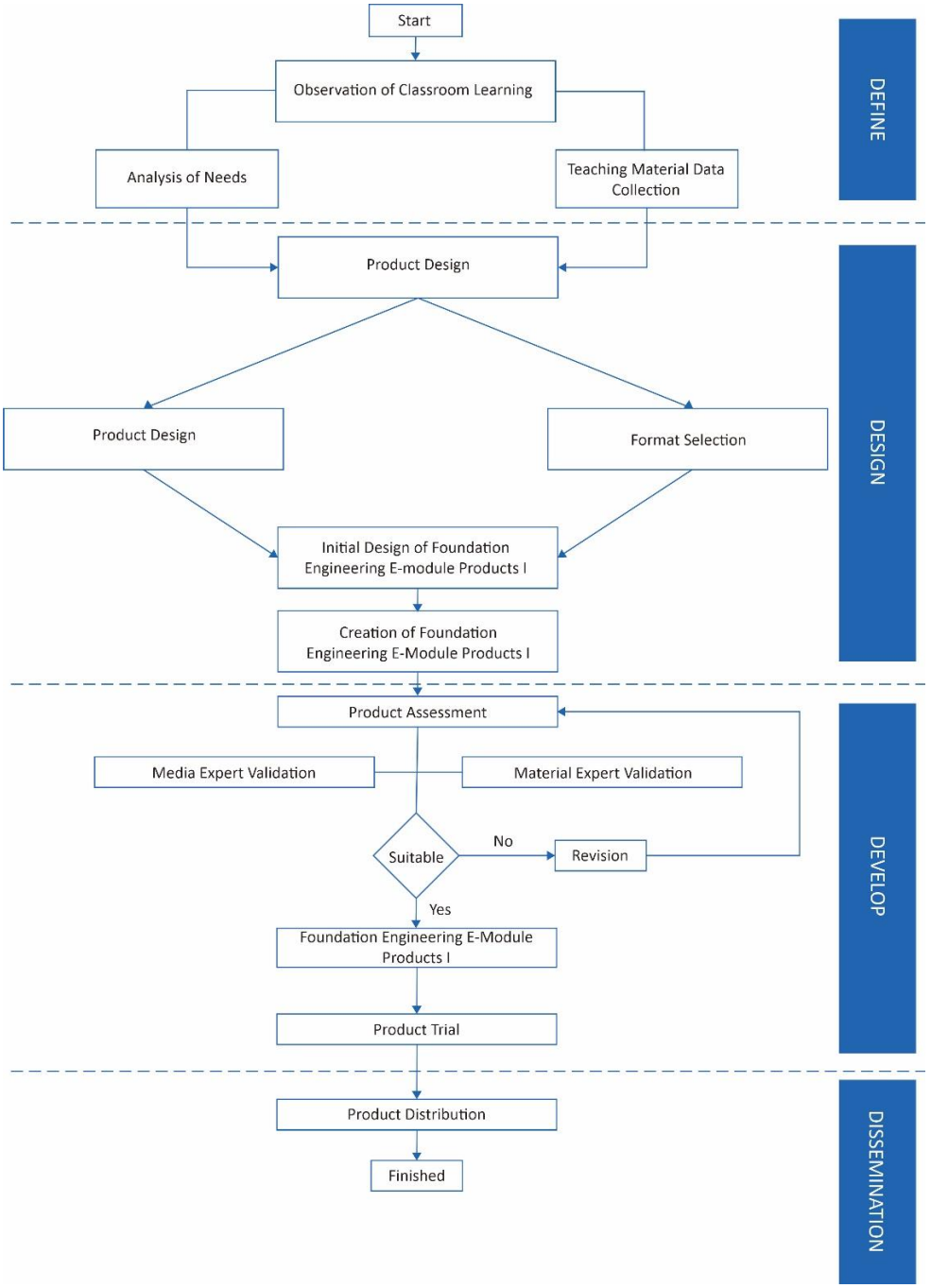

Figure 1. Research Flow for Development of the Foundation Engineering I E-module

3. Result and Discussion

This research produced a foundation engineering e-module product which was created using corel draw software for cover creation and microsoft office word for preparing material. This e-module is designed with various features, including illustrative images that support discussion, hyperlinks that facilitate navigation between pages, QR codes, and video links that are relevant to the material. At the end of the e-module there are summaries, exercises, assignments and evaluation tests, to determine students' ability to master the module [20]. The modules given to students and lecturers will be slightly different. Students are given modules based on the material, while modules for lecturers teaching foundation engineering courses will be given a complete version of the basic physics e-module which includes answer keys for each exercise. The product distribution will be carried out using the Learning Management System (LMS) In Building Engineering Education Study Program, State University of Jakarta. Figure 2 presents the results of the feasibility test that has been carried out as follows:

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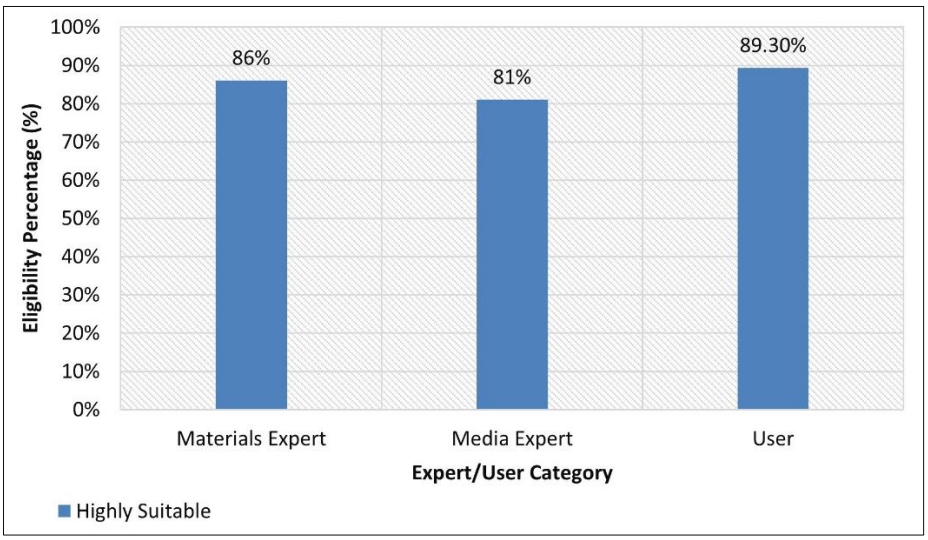

Figure 2. Results of Feasibility Tests that have been Carried Out

Based on Figure 2, the module that has been developed is considered very feasible in terms of material with a percentage of 86.0%. Material experts provide input and suggestions for the e-module for foundation engineering teaching materials, as follows: In section 1.1. Examples of wall cracks "Need to be sharpened" Structural wall cracks occur if the crack pattern is the same on the front and back views of the wall in question. If the pattern is not the same, it could be because the crack occurred due to improper and too thick plastering. According to media experts, the module that has been developed is very feasible with a percentage of 81.0%. The following comments and recommendations are made by media specialists for the foundation engineering e-module teaching materials: The module layout background is too firm, it should be made thinner, some parts of the illustrations are less clear and broken, the resolution should be increased and the examples are already available, only examples that do not contradict the correct examples need to be added.

Eligibility validation was also carried out directly by several students who successfully carried out independent learning with e-modules to completion. Based on the average percentage of 89.3%, It might be argued that the creation of e-module-based foundation engineering teaching materials is Highly Suitable. As for the comments and suggestions given by students regarding this e-module, on the one hand, some students stated: The e-module as a teaching material for foundation techniques is very interesting and can increase the learning motivation of its readers, the material presented is also clear and coherent so that users of this module understand what material is being discussed, plus the suitability of the writing with the images presented and the accuracy of providing feedback are also plus points in this module which are very influential in understanding the material.

The e-module design after revision is as follows: Next, the foundation engineering module was tested for its effectiveness to find out whether the teaching material product being developed could have an impact on students, especially in cognitive assessment [21]. The efficacy test in this research was carried out utilizing restricted trials and user assessments of the goods under development. Based on the findings and user evaluations of the product completed by limited trial participants following usage of the produced e-module, limited trials were conducted utilizing pretest and posttest methodologies. Limited trial participants are students of the Building Engineering Education Program Study class of 2021 with a total of 12 (twelve) participants. The findings of the limited study may be viewed in Table 3.

Table 3. Results of Pretest and Posttest Values for E-module Based Foundation Techniques

No.	Participant	Grade		
		Pretest	Posttest	Change (%)
1	Colleger 1	60	70	16.7
2	Colleger 2	80	90	12.5

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3	Colleger 3	70	80	14.3
4	Colleger 4	70	75	7.1
5	Colleger 5	65	85	30.8
6	Colleger 6	75	85	13.3
7	Colleger 7	70	80	14.3
8	Colleger 8	75	90	20.0
9	Colleger 9	60	85	41.7
10	Colleger 10	70	85	21.4
11	Colleger 11	75	75	0
12	Colleger 12	75	80	6.7
Average		70	82	16.6

Based on Table 3, it is clear that the average score attained by trial participants was limited to 70 in the pre-test exercises, The average score increased by 16.6% to 82 after taking the post-test. As a result, we can conclude that the average value of restricted trial participants increased by 16.6%. The learning outcomes also yielded an n-gain score of 0.60, indicating that the foundation engineering instructional material e-module falls into the medium effectiveness group. This supports the fact that the Foundation Engineering e-module teaching materials apart from getting a good response from students, the e-modules are highly suitable as teaching materials in the learning process. This research is relevant to previous research [15]–[17] in that this study was successful in creating an e-module, and the findings demonstrated that the created e-module was appropriate for usage.

Figure 3 shows the layout and content structure of the e-module for the "foundation engineering 1" course. This includes the cover page, introductory section on the understanding of foundations, and the section on soil investigation. The design appears to be visually organized with sections dedicated to theory, definitions, and supplementary video content, enhancing the learning experience through a structured and interactive approach.

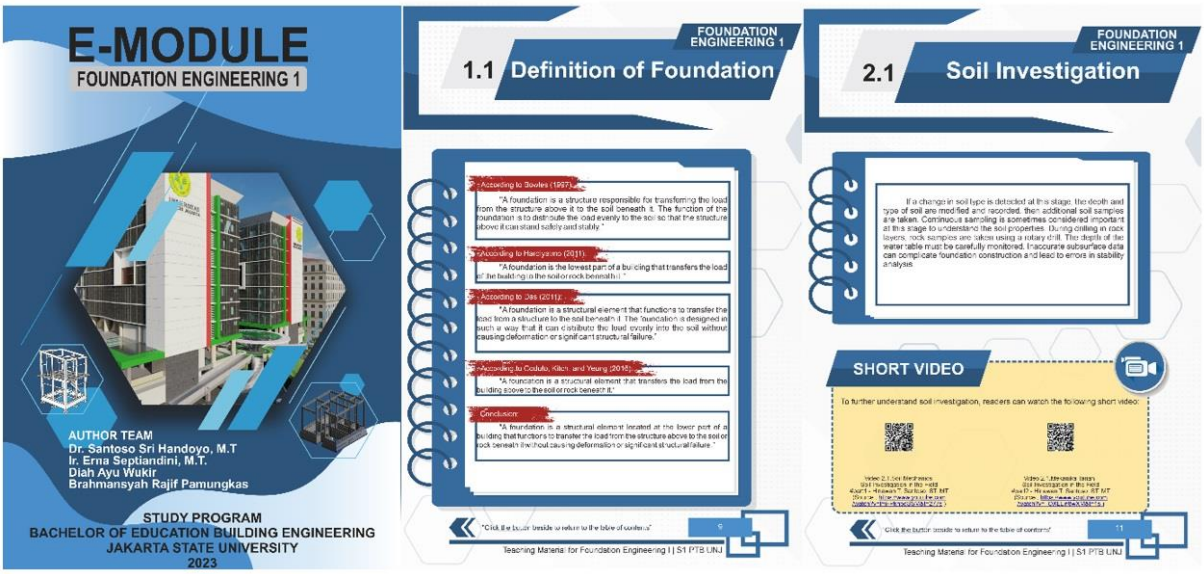

Figure 3. E-module Display

4. Conclusion

The conclusion that can be obtained from this research and development is that e-module teaching materials in foundation engineering courses have been developed through several stages of the 4D Thiagarajan method with several modifications. Starting with the define, design, create, and disseminate stages, it is possible to infer that the e-module development outputs are appropriate for usage by 86.0% of material experts, 81.0% of media experts, and 89.3% of users. These findings place the e-module in the highly suitable category of instructional materials in the learning process. According to the findings

of limited trials done on Building Engineering Education Students, there was a 16.6% improvement in student learning outcomes, with an average pretest score of 70 and an average posttest score of 82. Several recommendations were made in light of the findings from the study and creation of the foundation engineering course's e-module teaching materials. These included: The creation of instructional materials may be used as a tool to assist instructors in conveying foundation engineering subject, and it can be expanded upon by evaluating how well the final output facilitates learning.

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