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E-Module Development: Learning Innovation to Increase Students' Understanding of Building Materials Science

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Abstract: This study aims to develop e-module-based teaching materials for building materials science courses in the Building Engineering Education Study Program, Faculty of Engineering, State University of Jakarta. The method used in this research is Research and Development (R&D) with the 4D model consisting of Define, Design, Develop, and Disseminate. This research begins with the collection of needs analysis data through questionnaires, product design, product validation, limited product trials, and ends with user assessment of the products that have been developed. The results of material expert validation on e-modules were declared very feasible by obtaining a percentage of 89.39%, and media expert validation was declared very feasible with a percentage of 93.94%. The results of the limited trial on each e-module showed an increase in learning outcomes, and the e-module received a positive assessment from users by obtaining a percentage of 93.65% with a very feasible category. It can be concluded that e-modules can be used in learning building materials science courses in the Building Engineering Education Study Program, Faculty of Engineering, State University of Jakarta.

Keywords: Research and development, Teaching materials, E-module, Building materials science, 4D Models.

Introduction

In the current era of globalization, technology has experienced rapid development, marked by the large number of people who use information technology to meet their daily needs. The development of information and communication technology has had a significant impact on the education sector, especially on the teaching materials used in the learning process (Shobrina et al., 2020). Improving the quality of education does not only depend on choosing the right learning strategy or model, but must also pay attention to the teaching materials used in learning (Haikal et al., 2023). Education and teaching materials are two components that are closely related to each other. Education functions as a forum for the provision and development of teaching materials. The development of teaching materials itself is a process of creating new products from ones that did not previously exist, or to improve existing products to make them more suitable, more effective and more effective. Meanwhile, teaching materials act as a source of material that really supports the smooth learning process. In other words, without good teaching materials, the educational process will not run optimally. The development of appropriate and innovative teaching materials is very important to ensure that the material delivered to students is relevant, interesting and useful (Yazidah et al., 2021).

Teaching materials can be interpreted as a set of learning materials that have been arranged systematically and thoroughly describe the competencies that students will master in learning activities (Kurniawati, 2015). Teaching materials in their role as providers of information that is really needed by educators and students (Nuryasana & Desiningrum, 2020). Educators have an important responsibility to process any information presented so that it can be

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absorbed by students effectively. Utilizing teaching materials as a comprehensive learning resource allows students to deepen their knowledge in a more in-depth and structured manner. By using the right teaching materials, students will not only understand the material better, but will also be able to achieve better results. Well-designed teaching materials can inspire interest in learning, increase engagement, and facilitate better understanding. Therefore, educators must be careful in selecting and developing teaching materials that suit students' needs and abilities, so that the learning process becomes more effective and efficient.

The selection of good teaching materials must be adjusted to the students' circumstances, the capabilities of existing resources, and the availability of facilities at the educational institution. Innovative teaching materials are created by utilizing information technology, equipped with interesting content and illustrations, and easy to access anytime and anywhere. In addition, teaching materials that utilize technology can provide wider access and opportunities for students to build their own knowledge according to their needs (Juwati et al., 2021). Teaching materials consist of several types, namely: 1) Printed teaching materials such as handouts, modules, books, student worksheets, brochures, pictures and leaflets. 2) Audio teaching materials such as radio and cassettes. 3) Audio visual teaching materials such as video CDs, films, and 4) Interactive teaching materials such as interactive CDs.

Building materials science is a mandatory subject in the Building Engineering Education Study Program, Jakarta State University. The lecture uses an in-class learning system, and the teaching materials used are material presented in Power Point format, while the effectiveness of using Power Point is considered to depend only on the readiness of educators in compiling and delivering learning material. The material presented in Power Point is designed to display the main points, so it does not contain comprehensive material (Ramadhan et al., 2020). Building materials science includes knowledge about the materials and technology used in construction, including the characteristics and variations of building materials, their use, strength and preservation of building materials, maintenance techniques, as well as engineering aspects of building materials (Apriansyah, 2020) . In studying the science of building materials, comprehensive and structured teaching materials are needed. Therefore, there is a need for innovation in the learning process of building materials science, one of which is using tools or learning media that can present the material in full.

Based on the results of the needs analysis that has been carried out, with a total of 36 student respondents who have taken building materials science courses, 94.4% of students stated that the material provided or used by lecturers in teaching was in the form of PowerPoint, 50% strongly agreed and 38.9% agreed that the teaching materials provided by lecturers cause obstacles in understanding the material, 60% of students strongly agree and 40% of students agree that in the learning process for building materials science courses it is necessary to use innovative teaching materials and utilize technology, 80% of students state that teaching materials are suitable used for building materials science courses as a learning support, namely electronic modules. Apart from that, 77.8% of students strongly agreed and 22.2% of students agreed that the development of teaching materials for building materials science courses was carried out.

One of the developments in teaching materials that can be used to improve student experience is e-modules. E-modules can be interpreted as the development of printed modules in digital form that can display text, images, animations and videos that can be accessed via various devices such as computers, laptops or smartphones (Naufal Dzakwan et al., 2021). E-module is a type of teaching material that is arranged structurally and systematically. E-modules are designed to help teaching staff create an optimal learning environment for students, so that they can achieve previously created learning objectives (Ramadhina & Pranata, 2022). The use of e-modules in learning is considered a smart solution to overcome various problems that exist in learning activities and their use is not limited by place and time. E-modules can be considered good if they meet the following characteristics: (1) Self Instructional, which means students can learn independently and not depend on other parties, (2) Self Contained, meaning the learning material from one competency unit studied is contained within one e-module as a whole so that students can study the material completely, (3) Stand Alone, namely the e-module developed does not depend on other media or does not have to be used together with other media, (4) Adaptive, meaning E -modules should have high adaptive capacity to developments in science and technology and be flexible in their use, (5) User Friendly, namely making it easier for students to understand the material (straight language and easy to understand) (Syafa et al., 2022).

There are several studies that are relevant to the research topic that is being developed, including research (Suarsana & Mahayukti, 2013) which states that e-modules can improve students' thinking skills and provide a positive effect or impact on learning activities. Then the research results (Romayanti et al., 2020) stated that the use of e-modules had a positive effect in

allowing students to learn independently, both within and across the classroom. The results of several studies can be concluded that e-module teaching materials have a very important role in supporting the learning process to support innovative and efficient learning facilities.

Based on the description that has been explained and the results of the needs analysis which states that it is necessary to develop teaching materials that utilize technology, this is the reason for developing e-module based building materials science teaching materials. Meanwhile, the aim of this research is to produce teaching materials that are efficient and easy to use in the learning process in building materials science courses at the Building Engineering Education Study Program, Jakarta State University.

Method

This research was carried out at the Building Engineering Education Study Program, Faculty of Engineering, Jakarta State University from January 2024 to May 2024 with the aim of producing teaching material products in the form of building materials science e-modules. The population in this study were students of the Building Engineering Education Study Program, Jakarta State University who had taken building materials science courses. Research subjects were taken from this population, totaling 20 students. The research method used in this research is Research and Development (R&D), using a 4D model which has 4 main stages, namely: Define, Design, Develop, and Disseminate.

The define stage is the first stage in development, at this stage an analysis is carried out regarding development needs and the extent to which development needs to be carried out. The design stage is the second stage for designing a product to be developed. Develop stage, namely the e-module that has been designed will be assessed by media experts and material experts. And the final stage is dissemination which is carried out after the product has been revised based on input and suggestions for improvement from material experts and media experts. The 4D model is suitable for use in this research because it is more suitable for developing learning tools. Therefore, the 4D model is considered more systematic and detailed for developing e-module-based teaching materials in building materials science courses.

In this research, data collection techniques in the form of questionnaires will be used to determine the feasibility of the e-module that has been developed and user assessments of the e-module. The e-module feasibility assessment was carried out by material experts and media experts. Meanwhile, testing the effectiveness of e-modules is carried out through limited trials using pre-test and post-test methods, which are then followed by user assessments of the products that have been developed.

The data analysis technique used in this research is quantitative descriptive. Validation tests by experts and user assessments of the e-module will consider the material aspects and media aspects of the e-module, which are assessed based on a Likert scale, as seen in table 1.

Tabel 1: Likert Scale

Criteria	Score
Very Good	5
Good	4
Pretty Good	4
Not Good	2
Very Not Good	1

Source : (Pradana & Mawardi, 2021)

The results of the assessment scores are analyzed using the following calculation formula:

$$P = \frac{\text{Score obtained}}{\text{Maximum score}} \times 100\%$$

Information :

P = Percentage of eligibility

The eligibility percentage results obtained will be adjusted to the eligibility criteria contained in table 2 below.

Tabel 2: Eligibility Criteria

Percentage Score	Category
81% - 100%	Very Feasible
61% - 80%	Feasible
41% - 60%	Fairly Feasible
21% - 40%	Not Feasible
0% - 20%	Very Unfeasible

Source : (Pradana & Mawardi, 2021)

After carrying out validation tests by experts, the next stage is to conduct a limited trial on 20 students to determine the improvement in learning outcomes in using e-modules. The increase in learning outcomes can be calculated using the N-gain test. The following is the formula used for this calculation.

$$N - gain = \frac{S_{posttest} - S_{pretest}}{S_{maximum} - S_{pretest}}$$

Information :

$S_{posttest}$ = Post-test score results

$S_{pretest}$ = Pre-test score result

$S_{maximum}$ = Maximum score result

The N-gain results obtained will be adjusted to the N-gain criteria contained in table 3 below.

Tabel 3: N-gain Criteria

N-gain Score	Assessment Criteria
g < 0,3	Low rating
0,3 ≤ g ≤ 0,7	Medium rating
g > 0,7	High rating

Source : (Dewi & Yahya, 2022)

Result and Discussion

Result

A) Define Stage

Observations are carried out to collect various information regarding problems and development needs in order to determine relevant open materials. The results of the analysis and student problems are, the media used in learning is less interesting, the teaching materials used cause obstacles in the learning process, students need teaching materials that utilize technology, and students need learning products that suit students' needs and characteristics, namely electronic modules. Task analysis to identify the basic abilities that students need to master refers to the course learning outcomes, namely, being able to explain appropriate physical and mechanical property testing for various building materials, and being able to understand the types of building materials. Apart from that, concept analysis in this research is used to identify the material that will be presented in the e-module. There are 9 chapters of material that will be presented in the e-module based on the semester learning plan, namely: (1) Introduction to building materials science, (2) Concrete materials , (3) Steel materials, (4) Wood materials, (5) Asphalt materials, (6) Brick and concrete materials, (7) Plastic materials, (8) Glass materials, and (9) Renewable materials.

B) Design Stage

In the design stage, product design is carried out which is classified into three main parts, namely, the opening part consisting of a cover, e-module identity, foreword, instructions for using the e-module, table of contents, learning objectives, concept map and study instructions. The content section consists of learning material, material summaries, practice questions, formative tests, and a glossary. and the closing section consists of a bibliography and author's identity. The e-module was designed using Canva software, which is capable of designing with various templates and visually attractive design elements, and can be used for arranging text, images and other elements in a neat and structured format. The output used for e-modules is PDF (Portable Document Format), because this format can be accessed on various devices such as laptops, computers and smartphones. The e-module is equipped with learning video links that connect directly to YouTube, as well as navigation features that make it easier for users to access pages or sections of the e-module more quickly and easily. At the end of each e-module there is a summary, practice questions, and formative tests that provide direct feedback to determine students' ability to master the material studied.

Figures 1. E-module design

C) Develop Stage

The develop or development stage in this research aims to change the conceptual design of e-module based teaching materials into digital products that are ready to be used by educators and students. In addition, at this stage validation is carried out to ensure that the e-module that has been developed complies with quality standards and meets user needs. The e-module validation process involves material experts and media experts to obtain feedback which will be used for further improvements.

Material validation was carried out by three civil engineering lecturers who are experts in the field of building materials technology and have a minimum Master's degree. This validation includes several important aspects: suitability of content, language, and presentation. The content appropriateness aspect ensures that the e-module content is accurate and relevant to the learning objectives. The linguistic aspect assesses the use of language that is appropriate and easy to understand, while the presentation aspect measures how well the material is organized and presented visually. The results of material expert validation show that the building materials science e-module received an average assessment of 89.39% which is included in the very feasible category.

Media validation was carried out by three media experts who have expertise in the field of developing learning tools or educational technology, with a minimum qualification of a Master's degree. This validation process includes an assessment of various important aspects to ensure the quality of the e-module media. The first aspect assessed is the display design, which includes visual beauty and ease of navigation. The second aspect is usability, which measures the extent to which the e-module can be used easily and intuitively by users. In addition, graphic aspects are assessed to ensure the use of graphic elements that support learning and make the material more interesting. The validation results provided by the three media experts show that the building materials science e-module media obtained a percentage of 93.94% in the very feasible category. The results of the e-module validation can be seen in table 4Tabel 4: E-module Validation Result

Evaluator	Score obtained	Maximum score	Average Percentage
Material expert	295	330	89,39%
Media expert	310	330	93,94%

Source : Research Data

D) Disseminate Stage

The final stage is dissemination. At this stage, product trials and packaging of the products that have been developed are carried out. Limited trials were carried out on the e-module to evaluate its effectiveness in increasing students' understanding of the material being studied. The trial involved 20 students who had taken building materials science courses at the Building Engineering Education Study Program, Faculty of Engineering, Jakarta State University. The trial used pre-test and post-test methods via GoogleForm. The results of limited trials can be seen in table 5.

Tabel 5: Limited Trial Result

E-module	Pre-Test Average	Post-Test Average	Percentage Increase in Value	N-gain Score
1	39	77	38%	0.62
2	44	85,5	41,5%	0.74
3	42,5	86,5	44%	0.76
4	49	88	39%	0.76
5	44,5	86,5	42%	0,75
6	42,5	83,5	41%	0,71
7	41,5	83	41,5%	0,70
8	33	81	48%	0,71
9	37	82,5	45,5%	0,72

Source : Research Data

Based on table 5, it can be seen that the pre-test and post-test results show an increase in scores for each e-module. Apart from that, from the pre-test and post-test results, an n-gain score is obtained which will be adjusted to the n-gain criteria in table 3. E-module two, e-module three, e-module four, e-module five, e - module six, e-module eight, and e-module nine are included in the high n-gain level category because the g value is > 0,7. Meanwhile, e-module one and e-module seven are included in the medium n-gain level category because the g value is greater than or equal to 0.3 and less than or equal to 0,7 ($0,3 \leq g \leq 0,7$) . Furthermore, after a limited trial, a user assessment was carried out on the e-module that had been developed. This assessment consists of several aspects, namely aspects of the appearance of teaching materials, aspects of the use of teaching materials, aspects of the content of teaching materials, and aspects of evaluation of teaching materials. This assessment received a positive response from students, with a percentage of 93.65%, which is included in the very appropriate category.

After passing the product testing stage, the next step is the packaging stage. E-modules that have been successfully developed will be packaged in PDF format. However, the opportunity to integrate this e-module into the E-learning platform that is already available in the Building Engineering Education study program at Jakarta State University remains open, so that it can be accessed and utilized by more people.

Discussion

This research was conducted at the Building Engineering Education Study Program, Faculty of Engineering, Jakarta State University as a learning innovation aimed at producing products in the form of e-module teaching materials to increase students' understanding of building materials science. Based on the results of product validation, this e-module material received an assessment of 89.39%, this percentage shows the e-module is in the "very suitable" category for use as teaching material in building materials science courses. The assessment carried out by material experts shows that the e-module not only meets academic standards but also provides a good learning experience for students. Meanwhile, the media aspect received an assessment of 93.94%. These results indicate that the e-module is in the "very suitable" category for use as teaching material. The results of the assessment also show that the e-module has been well designed, easy to use and visually attractive.

Apart from that, limited trials through pre-test and post-test showed an increase in scores for each e-module. Seven e-modules obtained an n-gain score of more than 0,7 (g value > 0,7), which indicates that these e-modules are very effective, while the other two e-modules are in the medium effectiveness category because the g value is greater or equal to 0,3 and less

than or equal to 0,7 ($0,3 \leq g \leq 0,7$). So it can be concluded that the e-module that has been developed can increase student understanding. This e-module also received a positive response from students as users with an assessment percentage of 93.65%. These results show a high level of satisfaction from users or students with the teaching material products that have been developed.

Thus, it can be concluded that the teaching materials in the form of e-modules that have been developed are very suitable for use in learning building materials science courses. In line with research conducted by (Indra & Saleh, 2021) with the title "Development of an E-module for Concrete Stone Practices in the UNJ Building Engineering Education Study Program" which obtained a percentage of 88% for material validation in the very feasible category, and media validation results of 81.5% are included in the very feasible category. Meanwhile, the assessment results given by users for the e-module were 86% in the very good category

The e-module developed has utilized interactive technology which is able to increase student understanding and involvement in the learning process. This e-module integrates various multimedia elements such as images and videos which enable students to understand complex concepts more easily through dynamic visualization. Research (Alyusfitri et al., 2023) shows that e-modules with multimedia elements can improve information retention and better understanding of concepts compared to static text.

One of the main advantages of this e-module is its high accessibility, allowing students to access the material anytime and anywhere, both online and offline. This is different from printed modules or some previous e-modules which require a stable internet connection to access all content. Research (Rahmawati & Sujono, 2021) states that good accessibility really supports independent learning without being tied to a specific time and place, and helps students learn at their own pace and repeat the material as many times as needed to understand the concepts being taught. In this research, accessibility refers to the ability of e-modules to be accessed easily by all students, including students who have physical or geographical limitations, as well as overcoming the limitations of printed modules and some previous e-modules which require a continuous internet connection to access e-modules.

The e-module is also equipped with automatic evaluation and real time feedback features. This feature is a significant advantage compared to previous modules which may only provide evaluation at the end of learning without direct feedback. With automatic evaluation and real-time feedback, students can not only immediately find out their learning results, but also get specific and relevant suggestions for improvement. This allows for a more interactive and responsive learning process, where students can correct their mistakes directly and understand difficult material better. Apart from that, this feature helps increase learning motivation, because students can see their progress continuously and feel more involved in the learning process.

The material presented in the e-module refers to the Semester Learning Plan (RPS) for the building materials science course. This e-module contains an introduction to basic concepts and classification of building materials. The introduction to concepts in this e-module explains what is meant by building materials and their important role in construction, as well as classifying building materials clearly and structured. Furthermore, it contains a discussion of the physical and mechanical properties of building materials accompanied by physical tests and mechanical tests on building materials. The advantages and disadvantages of each building material are also explained. The purpose of this discussion is to understand the characteristics of various building materials, choose the right materials for various construction applications, develop new innovations in the field of building materials, and improve the quality of construction projects through choosing the right building materials. Apart from that, this e-module also explains the use of building materials in real construction, by including real examples and relevant case studies to help students link theory with practice in the field.

Conclusion

This research uses the Research and Development (R&D) method with a 4D model which includes the Define, Design, Develop and Disseminate stages. This research produces e-module based building materials science teaching material products. The material presented in each e-module refers to the Semester Learning Plan (RPS) for the building materials science course. The research results show that the building materials science e-module is included in the very feasible category in terms of material with a percentage of 89.39%. and the media obtained a percentage of 93.94% in the very worthy category. The results of implementing limited trials on each e-module show an increase in student learning outcomes. Apart from that, the e-module received a positive response from students as product users with a percentage of 93.65% in the very feasible category. So it can be concluded that the building materials science e-module can be used in learning in the Building Engineering Education Study

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