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E-Bricks and E-Tiles: The Helping Apps to Development and Evaluate of Competency-Based E-Modules in Building Material Science Course

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Abstract:- A profound understanding of building materials plays a crucial role in the civil engineering industry. However, laboratory practices in engineering education still face challenges in their effectiveness. Therefore, the development of competency-based e-modules, which include e-Bricks and e-Tiles, is considered a promising solution in enhancing the quality of Building Materials Science education. This research aims to develop competency-based e-modules and evaluate students' competency levels in cognitive, psychomotor, and affective aspects. The research method involves the development and validation of e-modules, as well as data collection from 33 Building Engineering Education students who use the e-modules. The research results show that competency-based e-modules effectively enhance students' understanding and competency in Building Materials Science, evidenced by significant improvements in cognitive, psychomotor, and affective aspects. It also makes a significant contribution by enabling students to learn independently, discuss in virtual classes, perform reciprocal task assessments, and assess their own competencies in the context of building engineering education. The development of competency-based e-modules has the potential as an effective and efficient learning method. Future research is suggested to further develop these e-modules by involving a more representative sample for more generalizable and applicable results.

Keywords*: competency, cognitive, psychomotor, affective, e-module feasibility.*

1. Introduction

Building Materials Science is a mandatory course in the civil engineering department, encompassing various knowledge related to various types of materials and building material technologies. This field involves understanding the properties, types, and applications of materials, as well as the strength, preservation, and testing of building materials. This course plays a crucial role in preparing students for the engineering industry, where the correct selection of materials is vital for sustainable construction practices [1].

Laboratory practice holds a significant position in the engineering curriculum, providing students with hands-on experience in testing and analyzing building materials. It has been an integral part of engineering education for years, emphasizing the practical application of materials and energy for the benefit of society [2]. However, the emphasis on laboratory practice continues to change over time, and challenges still exist in optimizing its effectiveness. Practical learning involves materials such as sand, cement, bricks, tiles, ceramics, wood, asbestos, and various metals [3]. Its primary goal is to equip students with competencies that are crucial for the industrial world, ensuring they can make decisions in accordance with industry standards.

Despite the importance of laboratory practice, challenges arise in the delivery of material and understanding of theoretical concepts. The use of worksheets has not been fully maximized, causing confusion among students during the practicum stage. The conventional delivery of material hinders optimal understanding, making students

struggle in the practicum process [4]. This poses a significant challenge in achieving the desired competencies and demands innovative solutions in teaching methodology.

Learning obstacles are reflected in the insufficiency of student competency achievement. Student completeness, as observed over the past three years, has not reached the expected standards, indicating a gap in the current teaching approach. In addition, the lack of implementation of competency-oriented learning and the absence of concrete situations or direct experiences hinder the effectiveness of learning tools in providing detailed information about practicum steps [5]. The faculty team acknowledges the limitations of resources and the need for an updated approach to enhance student competencies.

To address these challenges, the research proposes the development of competency-based e-modules for the Building Materials Science course. These e-modules aim to provide detailed explanations about the creation of test objects and the process of testing the quality of building materials, offering a comprehensive learning tool that facilitates independent learning and competency achievement [6]. The goal is to bridge the understanding gap, create an interactive learning environment, and ultimately enhance student competencies in civil engineering education.

The research conducted by [7] highlights the importance of addressing these challenges to enhance learning experiences and outcomes in Building Materials Science. The proposed competency-based e-modules offer a promising solution to improve the quality of education in this field, aligning with the needs of both students and the industry.

This research generally aims to develop competency-based e-modules in the Building Materials Science course for Building Engineering Education students. More specifically, this research aims to determine the validation of competency-based Building Materials Science e-modules and determine the level of student competency in cognitive [8], psychomotor, and affective [9] aspects in the application of competency-based e-modules in the Building Materials Science course. It is hoped that this research can contribute to the development of more effective and efficient learning methods, as well as assist students in understanding and mastering Building Materials Science material better. In addition, this research is also expected to serve as a reference for further research in the same field.

2. Literatur Review

The development of Competency-Based e-Modules in the Building Materials Science course is a significant breakthrough. Specifically, these e-modules are designed to facilitate students in understanding and mastering the course material, while also assisting them in achieving the expected competencies. With the presence of these learning and practicum modules, the learning process becomes easier and more effective.

The Building Materials Science course is an engineering course with certain competency standards, where students are expected to explain the properties and functions of various types of materials, understand the basics of material testing techniques, and understand the standard coding of engineering materials. The implementation of laboratory activities in this course plays a crucial role in enhancing students' competency levels towards the presented material [9]. Fulfilling student competency standards in completing this course is vital for developing learning methods that can maximize each student's competency. Understanding and mastering building materials science material greatly determines a person's success in developing advanced abilities and competencies in the next material. Therefore, the development of learning tools in the form of competency-based e-modules is necessary to enhance students' competencies in this course [10]. With these e-modules, students can learn more effectively and efficiently, thus achieving the expected competencies.

Knowledge can be classified into three main groups, namely knowledge about specific things which includes knowledge about specific terms and facts; knowledge as a method or way and source for solving something, which includes knowledge about rules, norms or regulations, sequential relationships between things, classifications and categories, criteria, and methodology; and knowledge as something universal and abstract, which includes knowledge about principles and generalizations, as well as theories and structures [11]. The term "knowledge"

itself is often used to refer to facts and principles that have accumulated over human time, covering various aspects, ranging from specific things to more universal and abstract concepts.

Psychomotor competency consists of six levels, namely skills based on cognitive understanding or perception related to the use of senses to obtain instructions, skills based on readiness including mental, physical, and emotional readiness to act, and skills due to guidance which is the first step in learning complex physical skills. In addition, there are skills based on habits that show learned responses become habits with proficient and confident movements, skills based on adjustments which are physical skills that have developed very well so they can change patterns to adapt to new situations, and skills related to the creation of new movement patterns to adapt to situations or problems, which emphasize creativity based on high-level and complex skills [12]. Meanwhile, affective domain competency includes behavioral characteristics such as feelings, interests, attitudes, emotions, or values. These three domains are human characteristics as a result of learning in the field of education. The affective domain determines a person's learning success, and people who do not have an interest in certain subjects will find it difficult to achieve optimal learning success [13] [14].

e-Modules, which are modifications of conventional modules with the incorporation of information technology, are designed to be more engaging and interactive with the addition of multimedia facilities such as images, animations, audio, and video. As a learning tool, e-modules contain material, methods, limitations, and evaluation methods that are systematically and attractively arranged, used independently to achieve the expected competencies according to the level of complexity. With a gradual search pattern approach for asynchronous and programmatic learning, this module can be used independently and is capable of self-teaching [15]. The purpose of the e-module and the ultimate goal of the module are formulated clearly and measurably. The material is packaged in small and complete units, equipped with examples, clear illustrations, exercise questions, tasks, and the like. In addition, there is a summary of learning material and assessment instruments that allow students to self-assess. Thus, this e-module provides a comprehensive and effective learning approach.

Competency-based e-Modules can be used in practicums as a medium for transforming knowledge, skills, and work attitudes to achieve Competency Standards, which are based on the achievement of learning objectives in theory and practice of Building Materials Science. The main characteristic of competency-based learning is its focus on the level of mastery. In addition, e-modules can be used to evaluate students' understanding, allowing students to see their own competency achievements. The learning system with competency-based e-modules is a series of learning that involves stages of competency mastery gradually until completion, before proceeding to the next stage of competency mastery [10]. Thus, these competency-based e-modules provide a structured and effective learning approach.

The implementation of student competency learning in the Building Materials Science course needs to be developed concretely by creating an active, interactive, creative, and effective learning situation, and maximizing the use of various existing infrastructures. The purpose of the preparation or creation of e-modules is to enable students to learn independently with minimal guidance from lecturers, reduce the dominance and authority of lecturers in learning activities, and train students' honesty in completing each stage of activities. The implementation of competency-based Building Materials Science modules can contribute to the achievement of students' theoretical and practicum competencies in accordance with the competency standards set in the semester course plan [16]. Thus, this e-module provides a structured and effective learning approach.

This achievement is proof of the success of lecturers in teaching activities and helping students achieve their competencies. The application of competency-based Building Materials Science modules is expected to enhance students' cognitive, skills, and affective [17] [18] [19], increase their knowledge about both the main material and supporting material, and provide learning experiences in Building Materials Science. This module is also beneficial for lecturers in accelerating learning time and facilitating the monitoring of student learning activities as well as providing individual guidance. The development of competency-based learning e-modules [16] is expected to assist students in solving problems related to the testing of building material quality in the Building Materials Science course correctly and accurately. Learning achievement, which is determined based on student

competency achievement, includes cognitive aspects with a minimum score of 75 [20], psychomotor with a minimum score of 75, and affective with a minimum score of 3 to 5.

3. Research Method

This research was conducted in the Civil Engineering Department, Faculty of Engineering, State University of Surabaya, Indonesia. The subjects of the study were 33 students from the Building Engineering Education Study Program, Civil Engineering Department, who were undergoing the 2020/2021 academic year. The object of research is the competency-based e-modules used in the Building Materials Science course, which includes two modules, namely e-Bricks and e-Tiles.

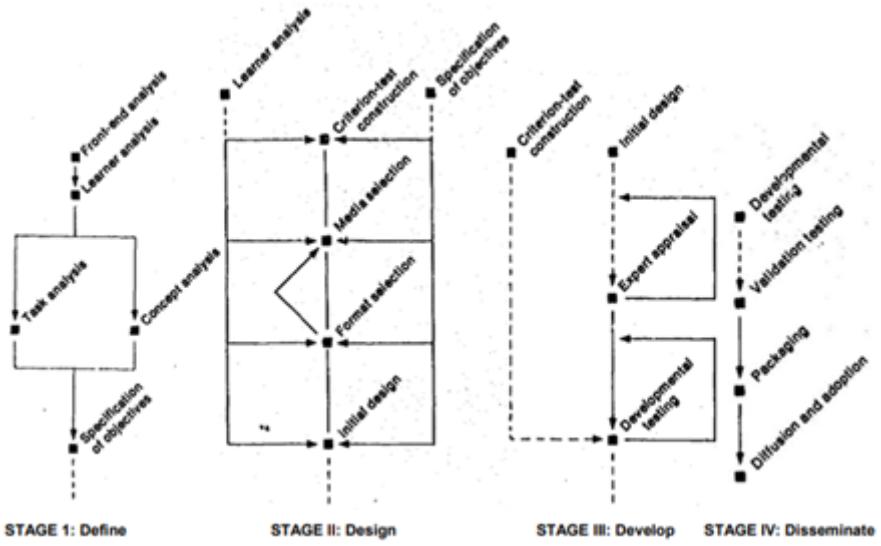

Figure 1: Stages model 4D by Thiagarajan [21]

This research design includes stages of competency-based e-module development, consisting of defining, designing, developing, and disseminating. The definition stage involves an analysis of the needs of Building Materials Science material, including competency standards and competency achievements, as well as student analysis, concepts, and tasks to formulate learning objectives. The design and preparation stage of the e-module focuses on module content, including material/tutorial notes, videos, submissions, language implementation, and physical feedback. The development stage involves the validation of the e-module design by e-module experts and building materials science experts, as well as limited module trials to assess the feasibility of the e-module in terms of the competency of the student users of the module. Although the dissemination stage of the e-module on a larger scale has not been carried out, the dissemination of the e-module will be part of further research.

4. Result and Discussion

4.1: Description of Results Define and Design

This analysis refers to theoretical literature on competency standards. The research instruments used include: 1) a validation sheet in the form of a checklist, and 2) a competency test in the form of an e-module material test. The data collection method used is expert validity, which is carried out through a validation sheet to collect e-module feasibility data. This assessment is carried out by lecturers who are experts in building material testing [22] and who are experts in the field of modules and learning tools. Competency tests in the form of learning outcome tests are used to assess student learning outcomes over a certain period of time. The competency tests provided are in the form of material questions that have been taught in the module, where the assessment is carried out for aspects: cognitive [23], psychomotor, and affective [24]. The criteria for student competency achievement or competency fulfillment are determined based on a) cognitive aspects with a minimum score of 75; b) psychomotor with a minimum score of 75, and c) affective with a minimum basic competency. The need for building materials science material, student analysis, concept analysis, and task analysis have been carried out to

formulate learning objectives. At this stage, important concepts have been obtained as the basis for making Building Materials Science e-modules which include material 1 about "e-Bricks" and material 2 about "e-Tiles". The results of the analysis that have been carried out include competency standards, basic competencies, and e-module objectives.

Module 1 'e-Bricks' is aimed to assist students in achieving competency standards in testing the quality of brick materials in accordance with PUBBI 1982 [25]. This is part of the achievement of learning process outcomes and its ongoing development. The basic competencies expected include: physical testing of bricks, water absorption testing on bricks, and flexural strength testing of bricks. Meanwhile, Module 2 'e-Tiles' is designed with the aim for students to be able to conduct quality testing of tiles in accordance with PUBBI 1982. The basic competencies expected from this module include: physical testing of tiles, water absorption testing on tiles, water permeation testing on tiles, and flexural strength testing of tiles. Both of these modules are designed to assist students in achieving the expected competencies in building material testing.

The 'e-Bricks' module is designed with learning objectives that cover several aspects. Cognitive product aspects [26] involve explanations about the quality requirements of bricks, the creation of specimens for absorption and compressive strength testing, and quality testing. Cognitive process [27] involves the implementation of brick quality testing [28], including physical examination of bricks, water absorption testing, and compressive strength testing of bricks. In the psychomotor aspect, students are expected to be able to design brick quality testing and create test objects that will be tested for quality. The affective aspect focuses on the development of character behavior [29], including honesty, treatment, and responsibility. In addition, learning objectives also include the development of social skills [30], such as asking questions, giving ideas or opinions, being a good listener, and communicating. All these aspects are designed to assist students in achieving the expected competencies in building material testing.

The 'e-Tiles' module is designed with learning objectives that cover several aspects. Cognitive product aspects involve explanations about the quality requirements of tiles, the creation of specimens for absorption testing and flexural strength of tiles, and quality testing of tiles. Cognitive process involves the implementation of tile quality testing, which includes physical examination of tiles, water absorption testing on tiles, and flexural strength testing of tiles. In the psychomotor aspect, students are expected to be able to design tile quality testing and create test objects that will be tested for quality. The affective aspect focuses on the development of character behavior [31]. All these aspects are designed to assist students in achieving the expected competencies in building material testing.

The design of this competency-based e-module encompasses various elements, including content composed of lecture notes or tutorials, videos, and submissions, language applications, as well as physical feedback. The module design process is guided by experts, resulting in an initial draft. For instance, Module-1 "e-Bricks" has been designed based on these principles. For more clarity, refer to Figure 2 below.

Figure 2: Pages of e-Bricks and scan QR-Code"

4.2: Description of Development Results

4.2.1: Module Validation Results by Experts

The validation of the e-module is carried out by experts in the field of learning with the aim to refine and enhance the initial design. This validation process aims to strengthen the overall construction of the e-module before it is tested on students. A lecturer who has expertise in the substance of Building Material Science and experience in teaching building materials as well as in the field of education, especially as a teacher from field experience courses in schools [32] acts as a module validator. This process is crucial to ensure that the developed e-module meets high quality standards and is relevant to the learning needs of students.

Table 1. Validation results of each component of the competency-based building materials science e-module

e-Module Components	e-Bricks			Feasibility	e-Tiles			Feasibility
	V1	V2	X	%	V1	V2	X	%
1. Module content								
a. Note/Tutorial	4.13	4.00	4.06	81.25	4.50	4.63	4.56	91.25
b. Video	3.92	4.08	4.00	80.00	4.50	4.50	4.50	90.00
c. Submission	4.00	4.33	4.17	83.33	4.43	4.52	4.48	89.57
2. Language Apps	4.50	4.25	4.38	87.50	4.50	4.25	4.38	87.50
3. Physical Feedback	4.00	4.50	4.25	85.00	4.49	4.71	4.60	92.06
Means (X)	4.06	4.18	4.12	82.35	4.47	4.56	4.51	90.29

Based on the validation results, the competency-based e-Module for Building Material Science, specifically "e-Bricks", obtained an average score of 4.12 or a feasibility of 82.35%. The components in "e-Bricks" include: a) module content with an average score of 4.06 or 81.15%; b) language application of the module with an average score of 4.38 or 87.50%; and c) module feedback with an average score of 4.25 or 85%. Thus, the overall average score obtained is 4.12 or a feasibility of 82.35%, indicating that the module's assessment by the validator falls into the good or satisfactory category, that is, between scores 3-5. Therefore, it can be concluded that Module 1 "e-Bricks" is suitable and valid for use as a student learning tool in the Building Material Science course.

Table 2. Recapitulation results of the competency-based building materials science e-module validation results by the validator

e-Module Components	e-Bricks		e-Tiles	
	Average	Feasibility %	Average	Feasibility %
Module Contents	4.06	81.15	4.52	90.38
Language Apps	4.38	87.50	4.38	87.50
Physical Feedback	4.25	85.00	4.63	92.50
Means (X)	4.12	82.35	4.51	90.29

Based on the validation results, the "e-Tiles" module obtained an average score of 4.51 or a feasibility of 90.29%. The components in the "e-Tiles" module include: a) module content with an average score of 4.52 or 90.38%; b) language application with an average score of 4.38 or 87.50%; and c) physical feedback with an average score of 4.63 or 92.50%. Thus, the overall average score obtained is 4.51 or a feasibility of 90.29%, indicating that the "e-Tiles" assessment by the validator falls into the very good or very satisfactory category, that is, between scores 3-5. Therefore, it can be concluded that the "e-Tiles" module is highly suitable and highly valid for use as a learning tool in the Building Material Science course.

4.2.2: Student Competence with Competency-Based Building Materials Science e-Modules

The module trial is used as an effort to obtain quality input from students who use the module. The results of the cognitive competency of the product in Module 1 "e-Bricks" are competent as many as 25 students out of 33 students or 75.76% with an average score of 85, those who are not yet competent are 8 students or 24.24% with an average score of 59.38. The average score for the cognitive competency of the product for all students is 79.58, while 23 students or 69.70% are competent in cognitive process competency with an average score of 87.83, while 10 students are not competent or 30.30% with an average score of 60.50. Overall, the cognitive competency of students in Module 1 is with an average score of 79.17.

From the validation results, it can be concluded that students have achieved the standard of cognitive competency in Module 1, both for product cognitive competency and process, with an average score of 79.17 which is greater than the minimum standard score of 75. This indicates that "e-Bricks" is suitable and valid for measuring student cognitive competency [33] in the Building Material Science course. Meanwhile, out of the total students, 63.64% or 21 students have achieved psychomotor competency with an average score of 86.67, while 36.36% or 12 other students have not yet achieved competency with an average score of 64.17. Nevertheless, overall, the average score of student psychomotor competency is 78.48, which is greater than the minimum score of 75, thus the psychomotor competency of students is also declared satisfactory.

Based on the evaluation results, all students have achieved affective competency in character behavior with an average score of 3.68. Meanwhile, in the aspect of social skills, all students have also met the competency with an average score of 3.90. Overall, the affective competency of students in Module 1 achieved an average score of 3.79. The results of student competency after learning with "e-Bricks" are further explained in Table 3. This shows that "e-Bricks" has been successful in helping students achieve the expected competency.

Tabel 3. Recapitulation of student competences through learning module 1 "e-Bricks" in competency-based building materials courses

Student Competency	Score Criteria		Freq.	%	Average Score
cognitive	Incompetent	≤75	8	24.24	59.38
a. product cognitive	Competent	≥75	25	75.76	85.00
	Total		33	100	78.79
b. cognitive processes	Incompetent	≤75	10	30.30	60.50
	Competent	≥75	23	69.70	87.83

Tabel 3. (Continued)

Student Competency	Score Criteria		Freq.	%	Average Score
	Total		33	100	79.55
psychomotor	Incompetent	≤75	12	36.36	64.17
	competent	≥75	21	63.64	86.67
	Total		33	100	78.48
affective	Incompetent	1-2.99	0	0	0
a. character behavior	competent	3-5	33	100	3.68
	Total		33	100	3.68
b. social skills	Incompetent	1-2.99	0	0	0
	competent	3-5	33	100	3.90
	Total		33	100	3.90

In Module 2 “e-Tiles”, as many as 84.85% or 28 out of 33 students have achieved product cognitive competency with an average score of 96.43, while 15.15% or 5 students have not yet achieved competency with an average score of 65. For cognitive process competency, 81.82% or 27 students have achieved competency with an average score of 88.15, and 18.18% or 6 students have not yet achieved competency with an average score of 65.83. Overall, the average score of student cognitive competency in “e-Tiles” is 83.71, which is greater than the minimum standard score of 75. This indicates that students have achieved the standard of cognitive competency in the “e-Tiles” module, both for product cognitive competency and process. This shows that “e-Tiles” is suitable and valid for measuring student cognitive competency in the Building Material Science course.

It can be concluded that students have achieved the standard of cognitive competency in the “e-Tiles” module, both for product cognitive competency and process. With an average score of 83.71, which is greater than the minimum standard score of 75, the cognitive competency of students is declared satisfactory. This indicates that “e-Tiles” is suitable and valid for measuring student cognitive competency in the Building Material Science course [34].

In Module 2 “e-Tiles”, as many as 78.79% or 26 out of 33 students have achieved psychomotor competency with an average score of 89.04, while 21.21% or 7 students have not yet achieved competency with an average score of 67.14. Overall, the average score of student psychomotor competency is 84.39, which is greater than the minimum standard score of 75. This indicates that students have achieved a satisfactory standard of psychomotor competency, and that “e-Tiles” is suitable and valid for measuring student psychomotor competency in the Building Material Science course.

Based on the evaluation results, all students have achieved affective competency in character behavior with an average score of 4.10. In addition, all students have also achieved affective competency in social skills with an average score of 4.30. Overall, the average score of student affective competency in Module 2 is 4.20. These results indicate that students have achieved the expected standard of affective competency after learning with Module 2 “e-Tiles”. Please note that the table detailing the results of student competency is not displayed in this conversation.

Tabel 4. Recapitulation of student competencies through learning module 2 "e-Tile" in the competency-based building materials science course

Student Competency	Score Criteria		Freq.	%	Average Score
cognitive	Incompetent	≤75	5	15.15	65.00
a. product cognitive	Competent	≥75	28	84.85	96.43
	Total		33	100	83.33
b. cognitive processes	Incompetent	≤75	6	18.18	65.83
	Competent	≥75	27	81.82	88.15

Tabel 4. (Continued)

Student Competency	Score Criteria		Freq.	%	Average Score
	Total		33	100	84.09
Psychomotor	Incompetent	≤75	7	21.21	67.14
	Competent	≥75	26	78.79	89.04
	Total		33	100	84.39
Affective	Incompetent	1-2.99	0	0	0
a. character behavior	Competent	3-5	33	100	4.10
	Total		33	100	4.10
b. social skills	Incompetent	1-2.99	0	0	0
	Competent	3-5	33	100	4.30
	Total		33	100	4.30

Based on the implementation of learning using "e-Bricks" and "e-Tiles", students have achieved the acquisition of e-module material very well. This indicates that students have achieved both product and process cognitive competencies well, demonstrating mastery of the material. Therefore, it can be concluded that the "e-Bricks" and "e-Tiles" modules are suitable and valid for use by students in the learning process.

Based on the results of students' psychomotor competency achievement in the e-module, students have demonstrated excellent mastery of the material. This indicates that the "e-Bricks" and "e-Tiles" e-modules are suitable and valid for use in the learning process. This confirms that both modules are effective in helping students achieve the expected psychomotor competencies.

Based on the evaluation results, students have achieved excellent character behavior competency in the e-module, demonstrating adequate mastery of the material. This indicates that the "e-Bricks" and "e-Tiles" modules in the competency-based Building Material Science course are suitable and valid for use by students. In addition, students have also achieved excellent social skills competency in learning with "e-Bricks" and "e-Tiles", demonstrating a high level of competency in mastering the e-module material. Therefore, it can be concluded that the "e-Bricks" and "e-Tiles" modules in the competency-based Building Material Science course are suitable and valid for use by students in the learning process.

4.3: Discussion on Define and Design of Modul e-Bricks and e-Tiles

The researcher collects theoretical information from literature based on the standard of module writing. These standards encompass material in Building Material Science, which serves as a guideline in the preparation of the module. The components of the module include competency standards, basic student competencies, material requirements for Building Material Science, student analysis, concept analysis, and task analysis. From these components, a formulation of learning objectives is obtained. This formulation is initially carried out as a basis in the preparation or creation of the learning module.

A module is a systematically arranged and engaging teaching material, encompassing content, methods, and evaluation, which can be used independently by students. The content structure of the module includes an introductory component consisting of a description, module prerequisites, instructions for using the module for students and lecturers, the ultimate goal regarding module performance and success criteria, as well as the formulation of competencies to be achieved and student ability checks. The learning component includes lesson plans, time allocation, learning objectives, scope and breadth of content, learning resources, activity sheets (tasks), student worksheets, and answer keys. The evaluation component includes cognitive tests [35], skill tests, attitude tests including social skills and character behavior, answer keys, and assessment sheets.

The material in the developed module is tailored to the competency standards set out in the curriculum and semester lecture plan for the Building Material Science course. This course involves the implementation of quality testing work for building materials, including: (1) brick materials, and (2) tiles. From this stage, an understanding

of the important concepts that form the basis in the creation of the module is obtained, especially those related to the material in Module 1 ‘e-Bricks’ and Module 2 ‘e-Tiles’.

4.4: Discussion on Development of Modul e-Bricks and e-Tiles

4.4.1: Discussion on e-Modul Validation by Expert

Each module is validated based on content, language, and physical form components. Expert assessment of content components includes initial, learning, and evaluation aspects. Initial aspects include description, module prerequisites, usage instructions, ultimate goals, competency formulation, and student ability checks. Learning aspects include lesson plans, time allocation, learning objectives, scope and breadth of content, learning resources, activity sheets, student worksheets, and answer keys. Evaluation includes cognitive, psychomotor, and attitude tests in 'e-Bricks' and 'e-Tiles'. Expert assessment of the language component includes the use of terms, consistency in the use of Indonesian, language difficulty level, and language style. Expert assessment of the physical form includes clarity of print, presentation of images, overall module form, and module material quality. The validation results of the competency-based Building Material Science e-module by the validator indicate that Module 1 'e-Brick' and Module 2 'e-Tiles' are highly valid and suitable for use by students.

4.4.2: Discussion on e-Modul Validation by Expert

4.4.2.1: Student Cognitive Competence

The cognitive competency of students in the e-module, as shown by [36], has achieved the standard competency criteria, with more than 75% of students scoring more than 75. The average score of student cognitive competency in Module 1 'e-Bricks' is 79.17, while in Module 2 'e-Tiles' it is 83.71. From this data, it can be concluded that the cognitive competency of students, both in product and process, in 'e-Bricks' and 'e-Tiles' shows a very good level of competency. This indicates that Module 1 'e-Bricks' and Module 2 'e-Tiles' in the competency-based Building Material Science course are valid and suitable for use, especially for measuring the level of students' cognitive competency [37].

4.4.2.2: Student Psychomotor Competence

The psychomotor competency of students in the e-module has achieved the standard competency criteria, that is, more than 75% of students scored more than 75. The average score of student psychomotor competency in Module 1 'e-Bricks' is 78.48, while in Module 2 'e-Tiles' it is 84.39. From this data, it can be concluded that the psychomotor competency of students in 'e-Bricks' and 'e-Tiles' is very good. This indicates that Module 1 'e-Bricks' and Module 2 'e-Tiles' in the competency-based Building Material Science course are valid and suitable for use, especially for measuring the level of students' psychomotor competency.

4.4.2.3: Student Affective Competence

The affective competency of students in the e-module has achieved the standard competency criteria, with more than 75% of students scoring between 3 and 5. The average score of student affective competency in Module 1 'e-Bricks' is 3.79, while in Module 2 'e-Tiles' it is 4.20. From this data, it can be concluded that the affective competency of students, both in character behavior and social skills, in 'e-Bricks' and 'e-Tiles' shows a good level of competency. This indicates that Module 1 'e-Bricks' and Module 2 'e-Tiles' in the competency-based Building Material Science course are valid and suitable for use, especially for measuring the level of students' affective competency [38].

4.5: Contribution theoretically

Theoretically, the results of this study make a significant contribution to the evaluation of the effectiveness of competency-based e-modules: Although it has been mentioned that competency-based e-modules can enhance student competency achievement in Building Material Science courses, there is no information about the results of the effectiveness evaluation of these e-modules. The Results and Discussion section could include information about the testing and evaluation of these e-modules, including data on the improvement in student competency

achievement after using the e-modules. Comparison with other learning methods. It can compare the effectiveness of competency-based e-modules with other learning methods used in Building Material Science courses. This can provide a deeper understanding of the advantages and disadvantages of using e-modules as a learning tool. The impact of using e-modules on student motivation and engagement: In addition to focusing on student competency achievement, the results of this study can evaluate the impact of using e-modules on student motivation and engagement in learning. Information about the increase in student motivation and engagement can provide a more complete picture of the benefits of using e-modules. In the future, the development of e-modules in the form of competency-based e-modules is very much needed, in addition to e-modules, improvements or additional developments on e-module content, integration of more advanced interactive or multimedia features, or the use of more innovative learning approaches.

5. Conclusion

The content validation test results of the e-module by experts indicate that 'e-Bricks' and 'e-Tiles' are declared valid. This is based on the assessment of all components of each aspect of teaching materials, including the feasibility aspect of content, language aspect, as well as the physical form and appearance of the module, all of which are declared valid or very valid. In addition, the results of empirical validation trials on students in the form of competency achievement indicate that the module is suitable for use. Thus, both Module 1 'e-Bricks' and Module 2 'e-Tiles' in the Building Material Science course are deemed suitable for use by students.

For further development and to improve the quality of the product, a sufficiently long research and development time (multi-year) is needed so that the information provided in the product becomes more complete and always up-to-date. The next important step is to disseminate to introduce this research product, namely the competency-based Building Material Science e-module, by publishing a patent. This e-module is compiled based on the curriculum and semester lecture plan in the Civil Engineering Department, Building Engineering Education Study Program, so this product is intended for use by the concerned students. This product can also contribute to other departments if it is designed and compiled by adjusting the content of the material based on the field of study that will utilize it.

Conflict of Interest

The authors affirm that there is no conflict of interest in this article. This statement is important in maintaining the integrity and transparency of the research process.

Co-Author Contribution

All authors participated in conducting field research, preparing literature reviews, writing research methodologies, collecting and analyzing data, interpreting results, and reviewing article writing. This collaborative approach ensures a comprehensive and thorough examination of the research topic.

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