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THE EFFECTIVENESS OF LEARNING MANAGEMENT APPLICATION IN FOUNDATION ENGINEERING BASED ON E-MODULES IN THE BUILDING ENGINEERING EDUCATION PROGRAM, STATE UNIVERSITY OF JAKARTA

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Abstract

This study aims to evaluate the effectiveness of e-module-based learning in the Foundation Engineering I course. The research method employed is an experimental approach with two groups. The learning material consists of four learning activities (KB1, KB2, KB3, and KB4). The research instrument includes learning outcome tests conducted before (pre-test) and after (post-test) the learning process. The findings show that the experimental group experienced learning outcome improvements of 29.40% (KB1), 33.94% (KB2), 58.41% (KB3), and 24.51% (KB4). Meanwhile, the control group achieved increases of 25.74% (KB1), 31.67% (KB2), 51.80% (KB3), and 22.44% (KB4). The average learning outcome improvement in the experimental group was 36.49%, slightly higher than the control group at 32.93%, with a difference of 3.56%. However, statistical analysis revealed no significant difference between the two groups. This study indicates that e-modules are not yet fully effective in enhancing learning outcomes in the Foundation Engineering I course. The effectiveness of e-module-based learning is influenced by various factors, such as the e-module design, interactivity, and students' readiness to utilize technology. Additionally, the complexity of Foundation Engineering I material necessitates intensive guidance from lecturers to support mathematical and conceptual understanding.

Keywords: Effectiveness, E-module, Foundation Engineering

Introduction

Learning media have been shown to effectively improve student learning outcomes across various educational settings. Studies indicate that well-designed media can enhance students' understanding of lesson content, increase engagement, and promote active learning (Devega et al., 2022; Irmawan et al., 2021; Siregar et al., 2019). Additionally, the integration of learning media with discovery learning approaches has been found to positively impact student interest and performance (Dewi et al., 2024; Siregar et al., 2019). The development of appropriate learning media is crucial for addressing low student achievement and can significantly influence learning outcomes (Matje, 2022; Sahronih et al., 2019). To maximize effectiveness, learning media should actively involve students in the learning process, both mentally and physically, while also boosting their self-confidence (Matje, 2022). Therefore, the use of learning media is effective in increasing students' cognitive learning interest compared to not using learning media (Hidayat & Suryadi, 2023; Zahranisa et al., 2023).

The use of e-module-based teaching materials has grown significantly in Indonesia, driven primarily by two key factors: the impact of the COVID-19 pandemic and advancements in digital information technology (Supuwiningsih et al., 2023; Wirdiyatusyifa et al., 2022). The COVID-19 pandemic marked a turning point in education, prompting a major transformation in learning activities, shifting from face-to-face interactions to non-face-to-face learning methods (Salim, 2022). This shift is widely known as online learning or e-learning systems (Pritandhari & Wibawa, 2021). Post-pandemic, education has not entirely reverted to traditional methods. Instead, hybrid approaches and technology-based learning have emerged as solutions to address educational challenges in the digital era (Abdul Sakti, 2023; Singh et al., 2021). Technology is utilized to support learning processes, ensuring desired outcomes are achieved (Dianis Svari & Arlinayanti, 2024). The integration of digital technology in education not only served as a temporary solution during the pandemic but also created opportunities to enhance student motivation and engagement, improve teaching quality, expand access to information, and establish a more flexible, independent, and effective learning system (Baharuddin & Hatta, 2024).

Technology enables the development of e-module-based teaching materials (Lastri, 2023). In line with research conducted by Istiqoma et al. (2023), the use of electronic modules as learning media in the digital era 4.0 has been explored in various studies with positive results. E-modules are considered more accessible, portable, durable, and compatible with different types of learner devices, facilitating independent learning anytime and anywhere. In the post-COVID era, the application of e-modules has become increasingly relevant. E-modules support independent learning without the barrier of internet signal availability and provide a wealth of learning resources (Sarnoto, 2023). Numerous studies have demonstrated positive outcomes, showing that the use of e-modules positively impacts learning motivation, academic performance, and learner autonomy (Fianti, 2021; Islami & Armiati, 2020; Suwirno & Usmeldi, 2022).

E-modules have emerged as effective learning media for improving student outcomes across various disciplines (Pajriah et al., 2024; Sriyanti et al., 2021). Studies have shown that e-modules can significantly increase nursing students' knowledge (Syafitri & Kurniawati, 2023) and enhance economics students' learning outcomes by promoting critical thinking and problem-solving skills (Jaenudin et al., 2017). The interactive nature of e-modules, incorporating text, graphics, animation, and videos, has been found to boost student motivation, scientific literacy, independence, and critical thinking abilities (Holisoh et al., 2023). Furthermore, STEM-integrated e-modules have demonstrated effectiveness in improving student learning outcomes in physics, specifically in static fluid materials (Asrizal et al., 2022). These findings suggest that e-modules, when designed with interactive elements and integrated approaches like problem-based learning or STEM, can be powerful tools for enhancing student learning outcomes across cognitive and affective domains in both traditional and distance learning settings.

Research conducted by Handoyo et al. (2024) during the even semester of the 2023/2024 academic year developed e-module-based teaching materials for the Foundation Engineering course. The Foundation Engineering e-module consists of four sections (learning activities), namely: (1) Section I, which covers the definition of foundations, foundation classification, and selection of foundation types; (2) Section II, which discusses soil investigation; (3) Section III, which includes types of foundation failures, bearing capacity theories, bearing capacity from field test results, and soil settlement calculations; and (4) Section IV, which addresses isolated footings, strip footings, combined footings, cantilever footings, and raft foundations.

The results of material expert validation showed an average assessment percentage of 86%, while media experts provided an average assessment percentage of 81%. Thus, the development of the e-module-based Foundation Engineering teaching material falls into the "feasible" category for use. Meanwhile, student responses to the e-module-based Foundation Engineering teaching material were categorized as "highly feasible," with an average assessment percentage of 89.3%. Limited product effectiveness testing yielded an n-gain score of 0.60, indicating that the developed e-module-based teaching material is classified as moderately effective. Therefore, the development of this e-module-based Foundation Engineering teaching material is feasible for use in lectures and can enhance students' learning outcomes.

Although e-module-based teaching materials have been developed and have shown promising results in validation and limited trials, the effectiveness of their implementation within the framework of learning management still requires further investigation. Learning management encompasses three main aspects: planning, implementation, and evaluation of the teaching and learning process, with optimal utilization of e-modules as a learning medium (Utomo, 2018). As a core course in the Building Engineering Education program, Foundation Engineering demands a learning approach that not only focuses on theory but also supports in-depth mastery of concepts and calculations.

This study aims to examine the extent to which the implementation of the Foundation Engineering e-module supports the overall learning process. To assess the reliability of the Foundation Engineering e-module, which is expected to enhance comprehensive learning outcomes, the research aims to measure the effectiveness of e-module-based learning management in the Foundation Engineering I course. The study was conducted with 67 students enrolled in the Foundation Engineering course during the even semester of the 2023/2024 academic year.

Research Methods

The experimental research method used is a non-equivalent control group design, where two groups are given different treatments on the same subject matter. This research design involves two classes: an experimental class and a control class. Both the experimental and control classes are given a pre-test to obtain baseline data on their understanding of the Foundation Engineering I material. Following the pre-test, the experimental class (E) receives a treatment (X), while the control class (K) does not receive any treatment. After the treatment phase, both groups are given a post-test to assess their understanding of the material studied in each learning activity of the Foundation Engineering I e-module. The effect of the treatment on learning outcomes is calculated as follows: (O2 – O1) - (O4 – O3). The research design is illustrated as follows:

Table 1. Research Design

Class	Group	*Pre-Test*	*Treatment*	*Post Test*
A	E	O1	M	O2
B	K	O3	--	O4

The research was conducted in the Building Engineering Education Study Program, Faculty of Engineering, Universitas Negeri Jakarta (FT UNJ). The research took place from March to October 2024. The subjects of the study were students enrolled in the Foundation Engineering I course during the odd semester of the 2023/2024 academic year. The population consisted of all 67 students taking the Foundation Engineering I course. The sample for this research was the entire population, also known as a saturated sample. The sampling technique used was non-probability sampling. The sample was divided into two classes, as outlined below:

Table 2. Sample Size

Group	Number of Samples	Percentage (%)
Experiment	31	46.27%
Control	36	53.73%
Total	**67**	**100%**

The instruments used in this study included a learning outcome test, expert evaluations of test questions, and user assessments. The learning outcome test consisted of scores obtained from the test results. Data collection was conducted using pre-tests and post-tests to measure changes in learning outcomes before and after the treatment. The experimental class received treatment using the e-module, while the control class did not. The scoring for the pre-tests and post-tests employed a "right-only" method, where correct answers were awarded one point, and incorrect or unanswered questions received zero points.

Data analysis techniques included descriptive statistics to determine the mean, mode, and median scores, as well as inferential statistics to evaluate whether the proposed hypothesis was accepted or rejected, using normality tests, homogeneity tests, and T-tests. Additionally, to assess the improvement in students' cognitive learning outcomes after the treatment, the N-gain test was applied.

Research Results and Discussion

In the learning process of the Foundation Engineering I course in the Building Engineering Education Study Program, Faculty of Engineering, Universitas Negeri Jakarta, during the odd semester of the 2023/2024 academic year, the students' learning outcomes revealed differences in the average scores across the materials provided in both the experimental and control classes. Table 3 below present the pre-test and post-test scores of the students.

Table 3. Pre-Test and Post-Test Results for Learning Foundation Engineering I

No	Test	Average Score					
		Experimental Class			Control Class		
		Pre-Test	Post Test	%	Pre-Test	Post Test	%
1	LA 1	62.74	88.87	**29.40**	63.33	85.28	**25.74**
2	LA 2	46.45	70.32	**33.94**	44.03	64.44	**31.67**
3	LA 3						
	a. MC	36.13	64.03	**43.57**	35.58	52.22	**31.87**

	b. Essay 1	24.48	72.74	**66.35**	22.92	70.14	**67.32**
	c. Essay 2	25.65	73.39	**65.05**	35.97	82.50	**56.40**
4	LA 4	61.61	81.61	**24.51**	60.97	78.61	**22.44**

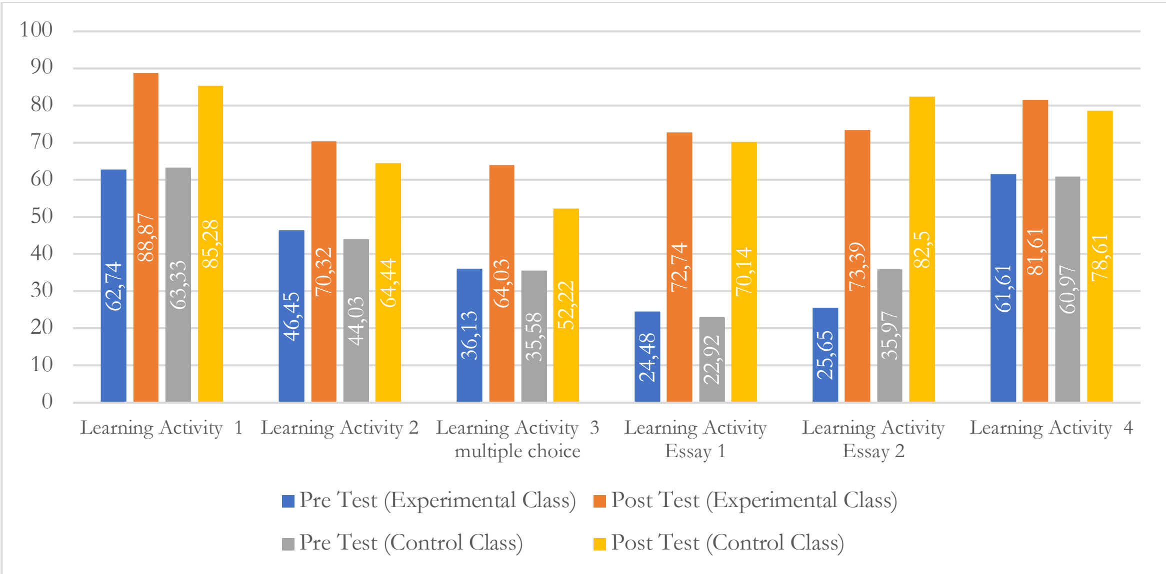

Figure 1. Comparison of Pre-Test and Post-Test Learning Outcome Data

In Learning Activity 1, the average improvement in learning outcomes for the experimental class was 29.40%, while the control class showed an average improvement of 25.74%. In Learning Activity 2, the experimental class demonstrated an average improvement of 33.94%, whereas the control class had an average improvement of 31.67%. In Learning Activity 3, the average improvement in learning outcomes for the experimental class was 43.57% for multiple-choice evaluations, while for essay evaluations, the improvements were 66.35% and 65.05%. Meanwhile, for the control class, the average improvement was 31.87% for multiple-choice evaluations and 67.32% and 56.40% for essay evaluations. In Learning Activity 4, the improvement in learning outcomes was the smallest compared to other learning activities. For this activity, the experimental class showed an average improvement of 24.51%, while the control class had an average improvement of 22.44%.

Statistical testing was conducted to ensure the validity of the research results. The Shapiro-Wilk test was used for normality testing, as the sample size in each class was less than 50. The normality test aimed to determine whether the data were normally distributed. A homogeneity test was performed to ensure that the two sample groups had equal variance. After the prerequisite tests were conducted to determine whether the data were normally distributed and homogeneous, hypothesis testing was carried out. Parametric statistics were used for materials with normally distributed and homogeneous data, while non-parametric statistics were applied for materials with data that were not normally distributed or homogeneous. For data that were not normally distributed and not homogeneous, the U-Mann Whitney test was used as a substitute for the Independent Sample T-Test.

Table 4. Data Normality Test Results Pre-Test Values for Experimental and Control Classes

No	Test	Experimental Class				Control Class			
		Shapiro - Wilk			Criteria	Shapiro - Wilk			Criteria
		Statistic	df	Sig.		Statistic	df	Sig.	
1	LA 1	0.894	31	0.005	Non-Normal	0.932	36	0.028	Non-Normal
2	LA 2	0.926	31	0.034	Non-Normal	0.942	36	0.057	Normal
3	LA 3								
	a. MC	0.908	31	0.011	Non-Normal	0.906	36	0.005	Non-Normal
	b. Essay 1	0.935	31	0.032	Non-Normal	0.915	36	0.009	Non-Normal
	c. Essay 2	0.941	31	0.060	Normal	0.915	36	0.009	Non-Normal
4	LA 4	0.932	31	0.087	Normal	0.932	36	0.021	Non-Normal

Table 5. Data Normality Test Results Post Test Values for Experimental and Control Classes

No	Test	Experimental Class				Control Class			
		Shapiro - Wilk			Criteria	Shapiro - Wilk			Criteria
		Statistic	df	Sig.		Statistic	df	Sig.	
1	LA 1	0.896	31	0.006	Non-Normal	0.905	36	0.005	Non-Normal
2	LA 2	0.899	31	0.007	Non-Normal	0.902	36	0.004	Non-Normal
3	LA 3								
	a. MC	0.927	31	0.037	Non-Normal	0.858	36	0.000	Non-Normal
	b. Essay 1	0.925	31	0.033	Non-Normal	0.960	36	0.218	Normal
	c. Essay 2	0.930	31	0.043	Non-Normal	0.934	36	0.033	Non-Normal
4	LA 4	0.933	31	0.052	Normal	0.946	36	0.081	Normal

Table 6. The result of the homogeneity test for pre-test data.

No	Test	Levene Statistic	df1	df2	Sig.	Criteria
1	LA 1	0.148	1	65	0.702	Homogenic
2	LA 2	0.595	1	65	0.443	Homogenic
3	LA 3					
	a. MC	0.127	1	65	0.723	Homogenic

	b. Essay 1	0.025	1	65	0.875	Homogenic
	c. Essay 2	1.158	1	65	0.286	Homogenic
4	LA 4	0.915	1	65	0.342	Homogenic

Table 7. The result of the homogeneity test for post-test scores.

No	Test	Levene Statistic	df1	df2	Sig.	Criteria
1	LA 1	0.295	1	65	0.589	Homogenic
2	LA 2	3.453	1	65	0.068	Homogenic
3	LA 3					
	a. MC	1.873	1	65	0.176	Homogenic
	b. Essay 1	5.990	1	65	0.017	Non Homogenic
	c. Essay 2	1.264	1	65	0.265	Homogenic
4	LA 4	1.546	1	65	0.218	Homogenic

Based on the results of the normality test using the Shapiro-Wilk test, the pre-test data in the experimental class showed that the evaluations for LA1, LA2, and LA3 (multiple choice and Essay 1) were not normally distributed, with significance values < 0.05. In the control class, the pre-test data for evaluations LA1, LA3 (multiple choice and Essay), and LA4 were also found to be non-normally distributed, with significance values < 0.05. Regarding the post-test data, the normality test results indicated that in the experimental class, the data for LA1, LA2, and LA3 (multiple choice and Essay) were not normally distributed, while LA4 was normally distributed with a significance value ≥ 0.05. On the other hand, in the control class, the post-test data for evaluations LA1, LA2, and LA3 (multiple choice and Essay 2) were not normally distributed, while LA3 (Essay 1) and LA4 were normally distributed. Therefore, most of the pre-test and post-test data in both classes were not normally distributed, which required the use of non-parametric tests for further hypothesis testing.

Furthermore, the results of the homogeneity test indicated that for the pre-test data, all evaluations in both classes had homogeneous variances, with significance values ≥ 0.05, meaning the data variability was balanced before the treatment was applied. However, for the post-test data, not all evaluations had homogeneous variances. Evaluations LA1, LA2, LA3 (multiple choice and Essay 2), and LA4 had homogeneous variances, while LA3 (Essay 1) showed non-homogeneous variance (significance value ≤ 0.05). These results form the basis for determining the appropriate analysis approach for each evaluation.

Based on the hypothesis test results using the U-Mann Whitney test, summarized in Tables 8 and 9, it was found that in the pre-test, only one material, LA2 (Essay 2), showed a significant difference in the average scores between the experimental and control classes. Meanwhile, the other five materials LA1, LA2, LA3 (multiple choice and Essay 1), and LA4, did not show significant differences. This is indicated by an Asymp. Sig. value > α table (0.05), meaning that H0 was accepted and H1 was rejected, suggesting that there was no significant difference in the average learning outcomes between the two classes in the pre-test.

In the post-test, the hypothesis test results revealed that only two materials showed significant differences in the average learning outcomes, namely LA3 (multiple choice) and LA3 (Essay 2). The other five materials LA1, LA2, LA3 (Essay 1), and LA4, did not show significant differences, with an Asymp. Sig. value > α table (0.05). Therefore, H0 was accepted and H1 was rejected for these materials, indicating no significant difference in the average learning outcomes between the experimental and control classes.

Table 8. Results of the Hypothesis Test for Pre-Test Data

No	Test	Asymp. Sig. (2-tailed)	Results	Criteria
1	LA 1	0.995	H1 Rejected	Ineffective
2	LA 2	0.308	H1 Rejected	Ineffective
3	LA 3			
	a. MC	0.819	H1 Rejected	Ineffective
	b. Essay 1	0.255	H1 Rejected	Ineffective
	c. Essay 2	0.000	H1 Rejected	Effective
4	LA 4	0.609	H1 Accepted	Ineffective

Table 9. Results of the Hypothesis Test for Post-Test Data

No	Test	Asymp. Sig. (2-tailed)	Results	Criteria
1	LA 1	0.995	H1 Rejected	Ineffective
2	LA 2	0.308	H1 Rejected	Ineffective
3	LA 3			
	a. MC	0.819	H1 Rejected	Ineffective
	b. Essay 1	0.255	H1 Rejected	Ineffective
	c. Essay 2	0.000	H1 Rejected	Effective
4	LA 4	0.609	H1 Accepted	Ineffective

In this study, learning outcomes are defined as the improvement in students' abilities that occurs during the learning process. Based on hypothesis testing, the materials with significant differences in results between the experimental and control classes were limited to two out of six materials taught, namely LA3 (multiple-choice questions) and LA3 (Essay 2). Therefore, an N-Gain analysis was conducted to measure the effectiveness of learning on these two materials, with the comparison results between the experimental and control classes presented in Table 10. The

N-Gain test results show higher effectiveness in the experimental class compared to the control class. For LA3 (multiple-choice questions), the average N-Gain in the experimental class reached 73.13% (moderately effective), while the control class only achieved 25.93% (ineffective). For LA3 (Essay 2), the N-Gain in the experimental class was 64.56% (moderately effective), which was higher than the control class at 44.07% (less effective).

Table 10. N - Gain Test Calculation Results

LA 3 (MC)			
Control Class		**Experimental Class**	
	N-Gain Score (%)		**N-Gain Score (%)**
Average	25.93	Average	73.13
Minimum	3.45	Minimum	41.67
Maximum	100	Maximum	93.75
Criteria	Ineffective	Criteria	Effective Enough

LA 3 (Essay 1)			
Control Class		**Experimental Class**	
	N-Gain Score (%)		**N-Gain Score (%)**
Average	44.07	Average	64.56
Minimum	7.14	Minimum	38.46
Maximum	92.31	Maximum	83.33
Criteria	Ineffective	Criteria	Effective Enough

Based on the results of the study, the average improvement in learning outcomes in the experimental class reached 36.49%, slightly higher than the control class at 32.93%, with a difference of 3.56%. This analysis indicates that although the experimental class showed a slight improvement, the difference was not significant. Therefore, the use of the e-module in the Foundation Engineering I course is considered ineffective in creating a noticeable impact compared to conventional teaching methods.

The use of the e-module in the experimental class was able to improve learning outcomes on some materials, especially in Learning Activity 3 (LA3). For LA3 multiple-choice questions, the experimental class achieved an average N-Gain of 73.13% (moderately effective), while the control class only reached 25.93% (ineffective). For LA3 Essay 2, the experimental class's N-Gain was 64.56% (moderately effective), higher than the control class, which only achieved 44.07% (less effective). This indicates that the e-module was effective in supporting understanding of relatively structured and focused material. However, the effectiveness of the e-module was not observed across all materials. In Learning Activity 4 (LA4), the improvement in learning outcomes was low in both classes, which was suspected to be due to the higher complexity of the material or limited learning time. The low results in LA4 highlight the need for the development of more adaptive module designs for complex materials.

These results support the findings of Hajar (2024), who stated that technology-based learning media can enhance conceptual understanding. This is corroborated by Mayer (2021), who highlighted that multimedia learning principles, such as the use of visual aids and animations alongside verbal explanations, effectively support students in mastering complex topics, particularly in STEM fields. Similarly, Lastri (2023) highlighted the role of e-modules in fostering students' understanding of specific subjects. This finding aligns with research by Hellín et al. (2023), who found that e-modules embedded with gamification elements, can motivate students and sustain engagement throughout the learning process. However, Susanto & Susanta (2022) cautioned that the effectiveness of e-modules depends heavily on their design quality, level of interactivity, and the learners' technological readiness. Poorly designed e-modules, which lack intuitive navigation, appealing visuals, or meaningful interactions, can result in cognitive overload and disengagement. Moreover, as Syefrinando et al. (2022) noted, students' digital literacy and access to reliable technology remain critical barriers in fully optimizing e-learning tools, particularly in regions with limited technological infrastructure. The study by Pertiwi et al. (2024) also shows that intensive lecturer guidance is necessary in teaching complex materials. This view is supported by Mohamed (2021), who observed that a blended learning approach, combining e-modules with in-person support, leads to better academic outcomes compared to using digital tools alone. Therefore, these studies suggest that while technology-based learning tools, including e-modules, hold immense potential for improving student learning outcomes, their effectiveness hinges on thoughtful design, integration with traditional teaching methods, and consideration of learners' technological preparedness.

In delivering complex learning materials, it can be balanced with learning media that adjusts between student characteristics with learning objectives and lecturer teaching styles. According to Ifenthaler & Yau (2020), incorporating analytics into learning media allows for a personalized experience, ensuring the level of complexity is appropriate for each learner. In addition, learning tools that facilitate collaboration can help learners tackle complex subjects by utilizing collective knowledge and peer support (Unal & Cakir, 2021). Therefore, for learning materials that are considered too complex can be equipped with personalized learning media in accordance with learning materials, lecturers' teaching styles, and student characteristics so that learning becomes more effective. One of the learning media that can be used is Multimedia because the principle of multimedia design is to apply the principles of coherence, signaling, and segmentation to help simplify complex information and improve student retention (Çeken & Taşkın, 2022; Mayer, 2021).

Conclusion

Based on the analysis and discussion of the effectiveness of the e-module as a learning media in the course of Foundation Engineering I at the Building Engineering Education Program, Universitas Negeri Jakarta, it can be concluded that the effectiveness of the e-module varies across the materials taught. The use of the e-module in Learning Activity 3 (LA3), particularly for multiple-choice questions and Essay 2, showed a relatively effective result in improving student learning outcomes, with N-Gain values of 73.13% and 64.56%, respectively. This indicates that the e-module supports understanding of structured and focused material. However, for Learning Activity 4 (LA4), the e-module was less effective, with low learning outcome improvements in both the experimental and control classes.

A recommendation for future research is that the e-module for Foundation Engineering I be further developed, particularly for LA4, which has a higher level of complexity. Development can focus on design aspects, adding interactive elements, visual simulations, and collaborative learning strategies. Additionally, more intensive lecturer guidance is needed to maximize the effectiveness of the e-module in teaching. This is expected to significantly and more evenly improve student learning outcomes across all materials.

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