A Pre-Experimental Study of Using E-Modules in Microteaching for Mathematics Pre-service Teachers

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Abstract. *Addressing pre-service teachers' lack of theoretical grounding in basic teaching skills, as revealed by preliminary interviews, this pre-experimental study evaluated cognitive learning gains and user acceptance of an LMS-integrated, Heyzine-based microteaching e-module for pre-service mathematics teachers. Using a One-Group Pretest-Posttest design ($n = 49$, purposive sampling), cognitive test and survey data were analyzed using a paired-sample t-test, Cohen's d, and Normalized Gain (N-Gain). Mean cognitive scores increased significantly from 85.30 to 96.84 ($t(48) = 7.015, p < .001$, Cohen's $d = 1.002$), with 77.55% of participants achieving high N-Gain (mean $= 0.7433$). User survey responses reached 91.12% ("very good"). The findings indicate that the interactive e-module is associated with measurable cognitive gains and high user acceptance, serving as a promising self-directed learning resource.*

Keywords: *Basic Teaching Skills, E-Module, Heyzine, Mathematics Education, Microteaching.*

Abstrak. *Mengatasi kurangnya pemahaman teoritis calon guru mengenai keterampilan dasar mengajar sebagaimana terungkap dari wawancara pendahuluan, penelitian pra-eksperimen ini menguji peningkatan hasil belajar kognitif dan respons pengguna terhadap e-modul Pembelajaran Mikro berbasis Heyzine yang terintegrasi dengan LMS. Menggunakan desain One-Group Pretest-Posttest ($n = 49$, purposive sampling), data tes kognitif dan kuesioner dianalisis menggunakan uji paired-sample t-test, Cohen's d, dan N-Gain. Rata-rata skor kognitif meningkat secara signifikan dari 85,30 menjadi 96,84 ($t(48) = 7{,}015, p < {,}001$, Cohen's $d = 1{,}002$), dengan 77,55% mahasiswa mencapai N-Gain kategori tinggi (rata-rata $= 0{,}7433$). Respons mahasiswa mencapai 91,12% (kriteria "sangat baik"). Temuan ini menunjukkan bahwa e-modul interaktif berkaitan dengan peningkatan kognitif yang terukur serta penerimaan pengguna yang tinggi sebagai sumber belajar mandiri.*

Kata Kunci: *Keterampilan Dasar Mengajar, E-Modul, Heyzine, Pendidikan Matematika, Pembelajaran Mikro*

INTRODUCTION

Educational quality depends heavily on teacher competence (Hanushek & Woessmann, 2012); Scheerens, 2004). In the digital era, teachers act as learning facilitators (Nst et al., 2025), requiring practical pedagogical competencies (Waluyo et al., 2025) embodied in eight basic teaching skills: opening and closing lessons, explaining, questioning, providing reinforcement, introducing variety, guiding small-group discussions, managing classrooms, and teaching small groups or individuals (Helmiati, 2013). Mastery of these skills defines teacher professionalism (Gusti et al., 2026). Teacher Education Institutions (*Lembaga Pendidikan Tenaga Kependidikan*/LPTK) foster these skills through microteaching courses, aligned with Permenristekdikti No. 55 of 2017 to ensure pedagogical readiness prior to school placement (Bano et al., 2025; Sukirman, 2012).

Despite being mandatory, microteaching often overemphasizes practical performance while neglecting theoretical foundations (Remesh, 2013), causing pre-service teachers to focus on superficial delivery mechanics (Mergler & Tangen, 2010). Preliminary evaluation data in the Mathematics Education program confirmed this gap, with 51.7% of students agreeing and 28.6% strongly agreeing on the urgent need for dedicated instructional modules. Preliminary qualitative interviews ($n = 7$) further revealed persistent skill execution obstacles and severe simulation anxiety due to insufficient theoretical grounding.

To address these challenges, digital technology integration must unite content, pedagogy, and technology under the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006). Interactive technology integration enhances pre-service teachers' TPACK competence, self-efficacy, and learner-centered perspectives (Ertmer & Ottenbreit-Leftwich, 2010; Satriawati et al., 2022; Sezaki et al., 2023) . In this study, TPACK guided the e-module design by combining pedagogical knowledge (eight basic skills), mathematical content (lesson plans), and technology (Heyzine multimedia and Untirta LMS), while aligning evaluation instruments with theoretical comprehension.

One application of technology is learning through e-modules. Electronic modules are the result of the development of printed modules into digital formats that are interactive, contain images, audio, and video, and feature easy navigation (Suarsana & Mahayukti, 2013, as cited in Roikha et al., 2023). The use of e-modules is considered effective in improving cognitive learning outcomes while also increasing student engagement, facilitating self-directed learning, and leading to better learning outcomes (Darpiyah & Sulastri, 2023). Iskandar & Wahidah (2023) noted that the use of e-modules as learning materials in lectures helps make learning more meaningful because they enable students to engage in self-directed learning. This self-directed approach aligns with the Self-Regulated Learning (SRL) framework, where students actively monitor and evaluate their own learning progress

(Zimmerman, 2002). Interactive e-modules foster SRL by allowing pre-service teachers to self-assess their basic teaching skills prior to practical simulations.

While interactive digital media have been increasingly utilized in higher education, comprehensive e-modules specifically designed to guide pre-service mathematics teachers in mastering the eight basic teaching skills remain limited. Therefore, an interactive e-module integrated with an LMS is needed to bridge the gap between theoretical pedagogical knowledge and practical microteaching simulations. To address these challenges, this study develops a microteaching e-module integrated with the Heyzine interactive platform and Untirta's Learning Management System (LMS) as a self-directed learning resource for pre-service mathematics teachers. Recent studies show that Heyzine Flipbook transforms static content into interactive, multimedia-rich modules, boosting student engagement and ease of access (Hutagalung & Ginting, 2025; Nisa et al., 2025). Furthermore, interactive e-modules have been demonstrated to support student learning outcomes and practical engagement across vocational and higher education contexts (Putri & Hakim, 2025). While web-based microteaching tools have been explored in recent literature (e.g., Sezaki et al., 2023; Sugihartini et al., 2025), the contribution of this study lies in offering an LMS-integrated, self-directed learning resource equipped with structured guidelines on the eight basic teaching skills to support pre-service mathematics teachers prior to their practical simulations.

METHODS

This quantitative study adopted a pre-experimental One-Group Pretest-Posttest Design (Cohen et al., 2018; Creswell, 2018), evaluating subjects before and after receiving an e-module intervention. Conducted in the Mathematics Education program at Universitas Sultan Ageng Tirtayasa in April 2026, the intervention spanned four weekly sessions. Preliminary semi-structured qualitative interviews with microteaching students ($n = 7$, reaching thematic saturation) identified two primary obstacles: severe simulation anxiety and overreliance on delivery mechanics lacking theoretical grounding.

Using purposive sampling, two intact microteaching classes ($n = 49$) were selected out of four available sections based on baseline academic homogeneity ($p > .05$). To mitigate researcher bias, classes followed a rotational team-teaching scheme where the researcher and a co-instructor each taught half the semester. Ethical protocols included informed consent, ID anonymization, and strict separation of course grading from research data collection. The study proceeded in three operational stages: (1) pre-intervention (instrument and e-module development, expert validation, and pretest administration); (2) implementation (deploying the Heyzine-based e-module via Untirta's Spada LMS, featuring audio guides, embedded videos, interactive exercises, and QR-coded lesson plans to support self-directed

learning); and (3) evaluation (posttest competency assessment and user response questionnaire administration).

Research data were collected using two main types of instruments that had undergone a qualitative validation process by two expert validators, two senior lecturers who teach microteaching. The instruments used were valid and reliable. Both the cognitive achievement test (pretest and posttest) and the student response questionnaire were validated through expert judgment and pilot-tested on 30 students who had previously completed the microteaching course. The cognitive test items met construct validity criteria ($r > 0.421$) and achieved good internal consistency reliability ($\alpha = 0.712$). Similarly, the questionnaire items demonstrated strong validity ($r > 0.530$) and high reliability ($\alpha = 0.781$). These empirical results confirmed that both instruments were valid and reliable for data collection. A total of 20 questions were administered before and after the use of the e-module. The second instrument was a student response questionnaire using a Likert scale to measure user perceptions following implementation. This questionnaire was designed in detail to collect data based on four main feasibility criteria: usability, utility, effectiveness, and attractiveness. Of the 16 statements in the student response questionnaire, four pertain to usability, four to utility, four to effectiveness, and four to attractiveness. A four-point scale was selected specifically to eliminate the neutral midpoint, thereby mitigating central tendency bias by encouraging respondents to express a definitive direction in their feedback (Garland, 1991). Students independently provided objective assessments of their learning experiences with the e-module.

In addition to quantitative data, qualitative feedback was gathered to obtain deeper insights into students' learning experiences with the e-module. A simple random sampling technique was used to select ten students ($n = 10$) from the participating cohort to provide qualitative reviews, open-ended feedback, and suggestions regarding e-module usability and practical implementation. These qualitative data were analyzed descriptively to complement and contextualize the quantitative questionnaire findings.

Data analysis of the test results was conducted using descriptive and inferential quantitative methods with the aid of the JASP statistical software. The inferential statistical method used was the paired t-test, which was employed to compare the means of two groups of data that are interrelated or derived from the same subjects, based on the pre-test and post-test results. To evaluate the extent of cognitive enhancement relative to the maximum possible improvement, normalized gain (N-Gain) scores were calculated according to Hake (1999). Rather than determining statistical significance, which was separately evaluated using a paired-sample t-test, the N-Gain metric measures the magnitude of relative learning gain achieved by students. The N-Gain score was computed using the following formula (Lestari & Yudhanegara, 2015).

$$N - Gain = \frac{Posttest\ score - Pretest\ score}{Maximum\ score - Pretest\ score}$$

Table 1 N-Gain Effectiveness Category Classification

Category	Range Value
High	$g \geq 0.70$
Medium	$0.30 \leq g < 0.70$
Low	$g < 0.30$

Data from the student response questionnaire were analyzed using a percentage-based feasibility technique for each assessment aspect. The cumulative percentage results were then converted into interval-based feasibility criteria to determine the levels of acceptance, satisfaction, and practicality of the e-modules in preparing prospective mathematics teachers with basic teaching skills.

RESULTS AND DISCUSSION

Results

Data collection for this study was conducted after the entire series of steps in the implementation of the microteaching e-modules had been completed in the two sample classes. To measure the degree of improvement in learning outcomes or the effectiveness of a treatment or intervention, pre-tests and post-tests were administered in class before and after the use of the e-modules. The following are the detailed results of the distribution of learning outcome improvement categories among the 49 respondents.

Table 2 Distribution of Improving Learning Outcomes Categories

N-Gain Category	Range Value	Number of students	Percentage
High	$g \geq 0.70$	38	77.55%
Medium	$0.30 \leq g < 0.70$	4	8.16%
Low	$g < 0.30$	7	14.29%
Total		49	100%

An interesting finding was the presence of an "undefined" category comprising 10 students. Methodologically, the presence of this data does not diminish the validity of the module's effectiveness; rather, it represents a group of students who already possessed a solid foundational understanding prior to the intervention.

The following table presents the descriptive statistics from the data collected in the study, along with a graph comparing the means from the pre-test and post-test.

Table 3 JASP Descriptive Statistics Output

Descriptive Statistics

	Pre-test	Post-test
Valid	49	49
Missing	0	0
Mean (arithmetic)	85.30	96.84
95% CI A. Mean Lower	82.01	95.16
95% CI A. Mean Upper	88.59	98.51
Std. Deviation	11.46	5.836
Skewness	-0.6176	-2.165
Std. Error of Skewness	0.3398	0.3398
Minimum	60.00	75.00
Maximum	100.0	100.0

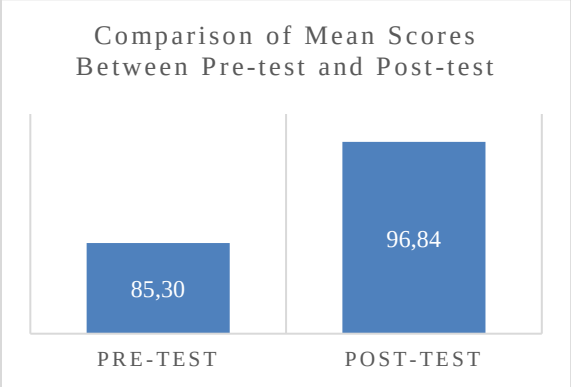


Figure 1 Comparison of Mean Scores Between Pre-test and Post-test

Figure 2 illustrates individual score trajectories, boxplots, and density distributions. Most participants displayed clear upward score trajectories following e-module implementation. However, a ceiling effect

occurred among students with maximum baseline scores (100), resulting in flat trajectories.

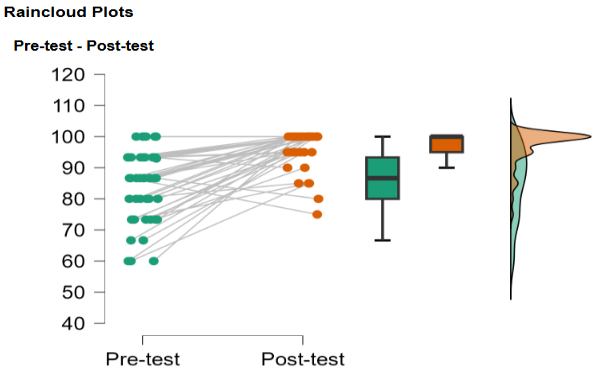


Figure 2 Score Trajectories

If the assumption of normality is met, the analysis can proceed using a paired t-test. The following is the output table from JASP for the Shapiro-Wilk test of normality.

Table 4 JASP Normality Test Output

Test of Normality (Shapiro-Wilk)				
	Test		W	p
Pre-test	-	Post-test	0.9599	.094
Note. Significant results suggest a deviation from normality.				

Based on the results of the normality test conducted earlier, which indicated that the data are normally distributed, the subsequent analysis used a paired-sample t-test. This test was used to analyze the difference in the mean pre-test and post-test scores within the same group in order to determine the effect of the intervention on students' learning outcomes. The following table presents the results of the paired-sample t-test.

Table 5 JASP Paired Sample t-test Output

Paired Samples T-Test

								95% CI for Cohen's d	
Measure 1		Measure 2	t	df	p	Cohen's d	SE Cohen's d	Lower	Upper
Post-test	-	Pre-test	7.015	48	< .001	1.002	0.2151	0.6545	1.343

Note. Student's t-test.

Next, to assess the suitability and user acceptance of the developed digital media, the author distributed a student response questionnaire following implementation. The processed data from the questionnaire covered four main evaluation aspects: usability, utility, learning effectiveness, and attractiveness. Details on the suitability scores for each evaluation aspect are presented in Table 6 below.

Table 6 Results of the Student Survey on the Use of E-Modules

No.	Aspect	Average per Aspect	Feasibility Percentage
1	Usability	3.81	95.27%
2	Utility	3.71	92.74%
3	Attractiveness	3.48	86.94%
4	Effectiveness	3.58	89.53%
Overall Average		3.645	91.12%
Interpretation		Very good	

The evaluation of the e-modules based on the four aspects above is further supported by the feedback provided by students regarding the e-modules used during the microteaching sessions. Some positive feedback on the use of the e-modules is presented in the following table.

Table 7 Review of the Use of E-Modules in Microteaching Class

Respondents	Review
1	This e-module helps me prepare to analyze more critically and develop lesson plans.
2	The e-module for microteaching has greatly enhanced my knowledge, and its design is also appealing.
3	The e-module helps me understand the eight basic teaching skills and improve my teaching abilities.
4	This e-module, which is easily accessible anywhere, makes things much easier and makes good use of technology. It also helps me mentally prepare before practice.

5	It's useful as reading material for students to improve their teaching abilities or skills.
6	The e-module is very helpful for learning, especially since it can be accessed anytime and anywhere.
7	Using this e-module is very efficient because it can be accessed at any time. Its navigation and design make it easy for me to find key points.
8	Using the e-module makes microteaching more engaging, interactive, and easily accessible anywhere. a PDF version is needed so it can be accessed offline.
9	Using the e-module in microteaching feels effective, practical, and helps me understand the material concisely and in a structured way.
10	Using the e-module in microteaching is quite helpful because the material can be accessed anytime and is presented systematically, making it easy to understand; plus, its interactive interface makes learning more engaging.

Discussion

Table 2 shows that of the total 49 respondents who took the pre-test and post-test, the majority of students (77.55%) fell into the high category, as their scores were within the range of g ≥ 0.70. Meanwhile, the moderate category included four students (8.16%), and the low category included seven students (14.29%). According to Coletta & Steinert (2020) respondents who are already at this very high level of mastery are generally excluded to avoid skewing the analysis of pedagogical effectiveness toward respondents who genuinely require improved understanding. Consequently, the number of respondents was reduced from 59 to 49. This situation occurred because the standard normalized gain (N-Gain) formula becomes mathematically undefined when a respondent achieves a maximum score (100) on the pretest, as the denominator (Maximum score – Pretest score) equals zero.

The predominance of students achieving N-Gain scores in the high category suggests that utilization of the microteaching e-module is positively associated with cognitive gains in mastering basic teaching skills, reflecting notable progress from baseline pretest performance. The mean N-Gain score of 0.7433 indicates that the intervention achieved a high category of cognitive knowledge gain. Similar high N-Gain values ($g > 0.70$) have been reported in e-module research across other higher education contexts, such as Elementary Linear Algebra $g = 0.867$ (Handayani. et al., 2023) and other relevant domains $g = 0.701$ (Darpiyah & Sulastri, 2023). However, these cross-study comparisons must be interpreted cautiously due to inherent differences in course content, target student populations, and test item difficulty. Overall, these findings suggest that the Heyzine-based e-module serves as an effective digital resource in enhancing pre-service teachers' conceptual understanding.

Based on Table 3, there was an increase in the students' mean score from 85.30 on the pre-test to 96.84 on the post-test. In addition, the standard deviation decreased from 11.46 to 5.836. The reduction in standard deviation suggests a narrower dispersion of posttest scores around the mean, indicating more

uniform cognitive achievement among pre-service teachers following the intervention. The results of the normality test on the difference between pre-test and post-test scores yielded a W value of 0.9599 with a p-value of 0.094. Given that the significance level (p) is greater than 0.05, it can be concluded that the data are normally distributed. Thus, the assumption of normality has been met, allowing the analysis to proceed using a paired-sample t-test.

As presented in Table 5, the paired-sample t-test revealed a statistically significant improvement from pre-test to post-test cognitive scores ($t(48) = 7.015, p < .001$). Thus, the post-test scores were significantly higher than the pre-test scores. Furthermore, the analysis yielded a Cohen's d value of 1.002 (95% CI [0.655,1.343]), indicating that the effect size of the e-module intervention falls into the 'large' category (Sawilowsky, 2009). These findings align with prior studies on e-module effectiveness, such as by Shelfia & Nuryadi (2025) in secondary education ($p < .05$) and Sugihartini et al. (2025) among prospective teachers ($p < .05$). Overall, the intervention demonstrated a statistically significant gain accompanied by a large effect size, suggesting a meaningful improvement in students' cognitive learning outcomes.

While student feedback regarding e-module usability was overall positive, constructive user suggestions provided crucial insights for iterative development. In response to student requests for offline accessibility, a downloadable PDF version was added at the end of the module. In previous research, the high effectiveness and positive responses were attributed to the interactive features of the e-modules and their ease of access (Maulana et al., 2022). The addition of interactive elements such as quizzes and other features can increase student engagement and retention of the material (Rahmiati et al., 2023). Empirically, instructional techniques such as dividing material into small segments and providing visual cues, bold text, or icons have been shown to be more effective (Sari et al., 2026).

The use of e-modules aligns with the theory of Self-Regulated Learning (SRL), in which social cognitive researchers examine the impact of modelling and student self-monitoring, which produce a reactivity effect. This effect implies the presence of students' metacognitive awareness, leading to positive personal changes (Zimmerman, 2002). The availability of videos showcasing best practices and implementation examples provides a model that helps learners engage in self-evaluation and self-improvement. Research by Sudrajat et al. (2024) on the application of Lesson Study-based Microteaching (LSbM) with pre-service teachers, in which they were asked to analyze video recordings of their teaching, revealed fundamental changes in the pre-service teachers' teaching patterns. Previously, they spent more than 50% of their time standing in front of the class giving instructions (teacher-centered); afterward, they allocated less than 25% of their time to explicit explanations in front of the class. This demonstrates a shift in the teacher's role toward that of a learning facilitator (student-centered).

Based on the results of the student response survey regarding the implementation of microteaching e-modules, which were analyzed using quantitative descriptive methods, it can be concluded that the developed e-modules received an exceptionally positive response from Mathematics Education students at the FKIP Untirta. The highest percentage was in the ease-of-use aspect, at 95.27%. In terms of usefulness, the e-modules received a percentage of 92.74%. Consistent with this study, the research by Putri & Hakim (2025) on the usefulness aspect yielded a score of 3.35 out of a maximum score of 4, representing 83.75%. This indicates that the module's content, including examples of scenarios integrating the eight teaching skills and practical guidelines, is considered highly functional in helping students develop instructional materials and conduct mathematics instruction.

For the third aspect the percentage was 86.94%. This indicates that the e-module's visual layout, illustrations, and navigation were deemed aesthetically pleasing and engaging. Furthermore, regarding the aspect of learning effectiveness, the percentage obtained was 89.53%, indicating high user acceptance and positive perceived effectiveness of the Heyzine-based e-module. It should be noted that this score reflects subjective student feedback regarding the module's usability and instructional clarity, rather than direct measurement of affective traits such as self-confidence or mental readiness. The overall student response in the study by Sugihartini et al. (2025) was highly positive, with an average of 85%. In accordance with Arikunto's (2010) criteria for interpreting scores, the four evaluation aspects mentioned above consistently fell within the range of 81.26% – 100%. Thus, it can be concluded that the microteaching e-module demonstrates positive student acceptance and measurable gains in cognitive comprehension. These findings indicate its potential as a supplementary interactive learning resource to support microteaching courses within the mathematics education program at Untirta.

CONCLUSION

Addressing the critical gap identified in pre-service teacher education, where students often engage in microteaching simulations without adequate theoretical grounding in basic teaching skills, this study demonstrates that an LMS-integrated, Heyzine-based interactive e-module serves as an effective self-directed learning resource. Rather than asserting absolute pedagogical mastery, the findings substantively signify that structured digital scaffolding facilitates measurable gains in cognitive comprehension while achieving high user acceptance across usability, utility, attractiveness, and instructional clarity. By successfully connecting theoretical knowledge with pre-practicum preparation, this intervention fulfills its primary objective of strengthening pre-service mathematics teachers' foundational understanding before they enter face-to-face teaching simulations.

Practically, this interactive e-module provides teacher education institutions with a

standardized framework for self-directed study to ensure baseline conceptual readiness prior to practical laboratory sessions. Nevertheless, these contributions must be contextualized within the study's methodological scope, which utilized a pre-experimental single-group design, a modest sample size ($n = 49$), and self-reported cognitive assessments susceptible to ceiling effects and instructor response bias. To build upon these findings, future research should adopt quasi-experimental or true experimental designs with control groups, employ assessment instruments with higher item difficulty, incorporate delayed posttests to evaluate long-term knowledge retention, and integrate observational rubrics to directly evaluate students' live classroom teaching performance.

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