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Effectiveness of Integrated E-Modules Combining Cooperative Learning and Videos in Enhancing Physics Teaching Skills of Pre-Service Teachers

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Abstract. Pre-service teachers' low physics teaching skills indicate a persistent gap between the demands of professional teaching standards and actual teaching readiness. This research aimed to investigate the effectiveness of integrated e-modules combining cooperative learning and videos in enhancing physics teaching skills of pre-service teachers. The research design employed was a quasi-experimental design involving two groups with a pretest–posttest structure. A total of 42 pre-service physics teachers were selected using purposive sampling and equally assigned to experimental and control groups. The experimental group received instruction through integrated e-modules, while the control group followed conventional learning. Teaching skill data were collected using a performance assessment sheet and analyzed using the Wilcoxon test for within-group improvement and the Mann–Whitney test for between-group comparisons. The results of the Wilcoxon test ($p < 0.05$) showed an improvement in teaching skills in both groups. However, the Mann–Whitney test ($p < 0.05$) revealed a significantly greater improvement in the experimental group. These findings suggest that the integrated e-modules combining cooperative learning and videos are more effective than conventional learning, with an effect size of 2.33, categorized as very large. Therefore, the integrated e-modules combining cooperative learning and videos are recommended for instructors to optimize pedagogical training for pre-service teachers. This study was limited to pre-service physics teachers. Future research should include other science disciplines and explore additional factors such as students' psychological characteristics and the integration of other innovative technologies.

Keywords: cooperative learning; physics education; pre-service teachers; teaching skills

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1. Introduction

In the last decade, the education sector has developed significantly, emphasizing academic achievement and mastery of 21st-century skills. 21st-century skills refer to abilities essential for individuals to adapt and succeed in the era of globalization and technological advancement (Varas et al., 2023). These skills include critical thinking, creativity, effective communication, collaboration, technological literacy, adaptability, and problem-solving (Thornhill-Miller et al., 2023). Mastering these skills has become a foundational requirement for building productive interaction, conveying ideas clearly, and working effectively in interdisciplinary teams (Almazroa & Alotaibi, 2023). Therefore, 21st-century skills are relevant and urgent for every individual, particularly in the context of education and the development of a competent and adaptive workforce.

In educational settings, communication is an important aspect of 21st-century skills that supports teacher–student interaction. This skill enables meaningful interaction between educators and learners, creating a contextual, innovative, and responsive learning atmosphere (Owens & Hite, 2020). Communication skills are crucial for success across various fields and have gained significant attention in education over the last decade (Albarra Shidiq et al., 2022; Priadi, 2020; Xie & Derakhshan, 2021). This competence includes both verbal and written communication abilities and serves as the foundation for effective interaction between teachers and students (Hargie, 2025).

In higher education, particularly in teacher education programs, communication skills are a prerequisite for developing professional teachers who can deliver content clearly, build pedagogical relationships, and transfer knowledge effectively (Yavuz Tabak et al., 2021). One aspect of communication skills is teaching skills, as the teaching process is closely linked to teacher–student interaction. Specifically, communication skills are essential in physics education to help students grasp abstract and complex concepts prone to misconceptions (Mufit et al., 2022). This is because physics is a discipline that requires systematic, logical, and structured explanations to help students understand natural phenomena comprehensively (Kulgemeyer & Wittwer, 2022). Therefore, pre-service teachers are expected not only to master conceptual understanding but also to be able to communicate it effectively and engagingly while teaching.

One aspect of teaching skills includes designing lesson plans, opening the lesson, delivering instructional content, and closing the lesson (Septiani et al., 2022; Sugihartini et al., 2025). These skills involve designing lesson plans and implementing them through effective communication, particularly during the opening and closing of lessons to make the material more engaging and relevant (Legrain et al., 2023). Opening the lesson inspiringly can boost students' motivation and focus, while a strong conclusion reinforces understanding and leaves a lasting impression of the content (Hawa et al., 2021). Training focused on developing these abilities is essential to support teaching skill development. One common training method in higher education is microteaching, a small-scale teaching simulation that allows pre-service teachers to practice their teaching skills directly.

In Indonesia, microteaching has become an essential component and even a graduation requirement for pre-service teachers (Marhaban et al., 2023; Sugihartini et al., 2021). This highlights the urgency of mastering practical teaching skills aligned with real classroom needs (Marhaban et al., 2023). Moreover, microteaching plays an important role in helping pre-service teachers develop socio-emotional competence, which is crucial for managing interactions with students during the learning process (Orr & Lavy, 2024). A solid command of microteaching enhances communication abilities and strengthens the capacity of pre-service teachers to write effective lesson plans, including managing lesson openings and closings professionally (Ledger & Fischetti, 2020). Microteaching is thus a strategic platform for preparing pre-service teachers for real-world teaching experiences (Wahida et al., 2022). However, challenges remain in using microteaching effectively to train physics teaching skills in pre-service physics teachers.

The main issue in developing physics teaching skills among pre-service physics teachers is their limited competence in designing and implementing effective teaching scenarios, especially in opening and closing lessons. Observations and microteaching practices show that many pre-service physics teachers are unable to create engaging lesson introductions, reinforce learning at the end, or write structured teaching scenarios (Hawa et al., 2021; Wahida et al., 2022). This weakness is compounded by limited communication skills, resulting in one-way classroom interactions with minimal student participation (Erdemir & Yeşilçınar, 2021; Nasution et al., 2023). Although microteaching is implemented, the approach remains conventional, focusing only on conceptual content and lacking systematic integration of innovative strategies and media (Nasution et al., 2023).

The low teaching competence among pre-service physics teachers and the ineffectiveness of existing methods highlight an empirical and practical gap that requires more relevant and contextual solutions. This situation underscores the need for innovative approaches to enhance learning effectiveness and teaching readiness. One potential solution is adopting relevant and innovative instructional materials such as e-modules. E-modules are digital teaching materials that provide flexible, efficient, and independent access to learning content (Astalini et al., 2019). They present structured and interactive content through multimedia integration, such as videos and simulations, to enhance conceptual understanding (Delita & Berutu, 2022; Logan et al., 2021).

However, for optimal implementation, a relevant instructional strategy is required. One promising strategy is cooperative learning, emphasizing small group teamwork with distributed roles and responsibilities (Khasawneh, 2023). This strategy also creates a supportive learning environment, allowing students to explore ideas without fear of making mistakes (Erdogan, 2019), and it has been shown to support physics concept comprehension among pre-service teachers (Dula et al., 2024).

Integrating e-modules with cooperative learning and videos represents an innovative solution to address the previously identified gap in developing physics teaching skills among pre-service teachers. This integrated approach combines structured and interactive learning content, collaborative environments, and contextual visual support. The synergy of these three elements represents a promising innovation for enhancing teaching skills more practically and contextually. Therefore, this study aims to evaluate the effectiveness of integrated e-modules that combine cooperative learning and videos in improving the physics teaching skills of pre-service teachers. The research was designed to answer several research questions to ensure that the study's objectives are addressed systematically.

1. How does the enhancement of physics teaching skills among pre-service physics teachers occur through conventional and cooperative learning strategies?
2. What is the effectiveness and effect size of learning with integrated e-modules combining cooperative learning and videos in enhancing the physics teaching skills of pre-service physics teachers?

2. Literature Review

2.1 E-Modules

E-modules are digital learning materials designed to provide flexibility in learning access and support students' independent learning. They present content in a structured and interactive format, accessible anytime through various digital devices (Astalini et al., 2019). One of the main advantages of an e-module is its ability to integrate various media such as text, images, audio, video, and interactive simulations to enrich the learning experience (Fimansyah et al., 2023). Research has shown that using e-modules can enhance learning motivation and student engagement due to their engaging and easy-to-understand nature (Delita & Berutu, 2022).

In the context of teacher education, e-modules are considered strategic tools for delivering pedagogical and content-area materials in a more structured and practical manner. They also offer opportunities for pre-service teachers to practice independently and reflectively in designing and implementing instruction. Several studies have reported improved pedagogical skills following the integration of e-modules in teacher training programs (Logan et al., 2021). Therefore, e-modules hold great potential to support teacher professional development, particularly in facilitating a deeper understanding of effective teaching practices.

2.2 Videos

Instructional videos are recognized as a visual medium capable of conveying concepts more clearly, concretely, and engagingly than text alone. Through visualization and simulation, video content can assist students in understanding abstract processes and enhancing information retention (Barut Tugtekin & Dursun, 2022). In physics instruction, videos enable the presentation of complex phenomena through demonstrations, virtual experiments, and interactive animations that are often difficult to implement in conventional classrooms (Mufit et al., 2022). Studies have indicated that using videos significantly improves students' motivation, conceptual understanding, and participation in the learning process (Kulgemeyer & Wittwer, 2022). For pre-service teachers, videos function as learning resources and tools for designing creative and responsive instruction. They can learn from modeled teaching practices in the videos while developing their video production skills for instructional purposes (Tugirinshuti et al., 2022). Integrating videos into instructional materials such as e-modules creates a multimodal learning experience that is both immersive and applicable (Kestin & Miller, 2022). Thus, videos constitute an essential component of integrated e-modules of cooperative learning, aiming to comprehensively and contextually enhance physics teaching skills.

2.3 Cooperative Learning

Cooperative learning is an active learning approach that promotes social interaction within small groups to achieve shared goals. In this model, each group member is responsible for completing part of the learning tasks (Møgelvang & Nyléhn, 2023). This model enhances conceptual understanding and cultivates social, communication, and leadership skills—critical competencies in the 21st-century context (Satriani, 2022). Research has shown that cooperative strategies significantly improve student participation and learning outcomes, including in science and physics domains (Møgelvang & Nyléhn, 2023). Specifically in pre-service teacher education, cooperative learning has proven effective in fostering reflection, professional collaboration, and the ability to manage classroom dynamics (Silva et al., 2022).

This model encourages pre-service teachers to comprehend the material and design instructional strategies that support student interaction and active engagement in the classroom. Recent studies indicate that applying this model in teacher training can enhance pedagogical readiness and reduce reliance on lecture-based instruction (Erdogan, 2019). Therefore, cooperative learning is considered a strategic approach well-suited for integration into interactive e-modules to support the development of teaching skills among pre-service teachers.

2.4 Teaching Skills

Teaching skills are recognized as core competencies that pre-service teachers must possess to deliver effective instruction. These skills include the ability to design lesson plans aligned with learning objectives and student characteristics, including selecting appropriate methods, media, and learning resources (Yeşilçınar & Aykan, 2022). Pre-service teachers must also be able to introduce lessons in engaging and communicative ways to foster students' motivation and readiness to learn from the beginning (Findeisen & Seifried, 2023). In addition, the ability to conclude lessons systematically and reflectively is essential for helping students consolidate knowledge and connect it with their learning experiences (Legrain et al., 2023).

Teaching skills involve planning and delivering instructional content as well as the ability to manage classroom dynamics effectively and respond sensitively to classroom interactions (Findeisen & Seifried, 2023). These competencies require pedagogical awareness and decision-making flexibility throughout the instructional process. Teachers with strong teaching skills are reflected in their performance in designing contextually appropriate lesson plans, implementing interactive instruction, and systematically evaluating learning outcomes (Van Katwijk et al., 2023). Such performance demonstrates the integration of pedagogical knowledge, didactic skills, and professionalism within authentic teaching contexts (Legrain et al., 2023). Before entering real classroom environments, pre-service teachers typically undergo a series of teaching practice activities through microteaching (Cavanaugh, 2022). This activity provides opportunities to practice teaching skills in a controlled setting, receive immediate feedback, and reflect on their strengths and weaknesses (Thangaraju & Medhi, 2023). Accordingly, microteaching has become an essential phase in shaping the professional readiness of pre-service teachers before they assume actual teaching responsibilities (Haruna Abubakar et al., 2023).

Various challenges often hinder this training process, including limited practice time, lack of constructive feedback, and insufficient use of diverse methods and media. Such limitations have prevented teaching practice from effectively addressing the complex and dynamic nature of 21st-century teaching demands. Several studies have revealed that many pre-service teachers, particularly in physics education, still lack optimal teaching skills across planning, implementation, and reflection domains (Hawa et al., 2021). This lack of skill poses a major barrier to improving education quality, as it impedes knowledge transfer and active student engagement (Wahida et al., 2022).

To overcome these challenges, there is a need for training strategies and instructional approaches that directly foster teaching skills through relevant, contextualized practice. Several scholars have recommended integrating innovative media and instructional methods to comprehensively and sustainably enhance pre-service teachers' pedagogical competence (Erdemir & Yeşilçınar, 2021; Wahida et al., 2022).

Integrating appropriate approaches, media, and instructional materials is increasingly required to support teaching skills development in physics education. Thus, improving teaching capabilities by adopting relevant instructional strategies and digital technologies has become a pressing need to ensure more contextualized, applicable, and effective learning processes. One relevant solution to enhance teaching skills among pre-service teachers lies in adopting educational technologies such as e-modules combined with innovative instructional approaches. The integration of e-modules with suitable teaching strategies offers several advantages, such as interactive, flexible, and context-rich content delivery. This approach is considered a promising solution to support more meaningful and effective learning aligned with the demands of 21st-century education.

3. Methodology

This research employed a quasi-experimental method to compare the differences in teaching skill enhancement between the two groups. The primary focus of the study was to compare pre-service physics teachers across the stages of pretest, treatment, and posttest. Each group received a different treatment to evaluate the effectiveness of the learning strategies implemented. Data from the pretest and posttest were analyzed to observe any improvements in teaching skills within each group. The complete design of this research is presented in Table 1.

Table 1: Quasi-Experimental Methods

Group	N	Pretest	Treatment	Posttest
Control	21	P1	Conventional Learning	P2
Experimental	21	P1	Learning with E-Modules	P2

Note : P1 = Pretest activity, P2 = Posttest activity

3.1 Participants

The population of this study consists of five classes of pre-service physics teachers from the physics education study program at Universitas Negeri Padang. The sample was selected using purposive sampling, as the same lecturer taught all five classes. Two classes were chosen as the sample, totaling 42 students, who were divided equally into experimental and control groups of 21 students each. Group assignments are based on intact class groupings rather than random individual assignments to maintain natural classroom dynamics. Both groups were tested for initial equivalence, and the results showed that their initial teaching skill scores were normally distributed and homogeneous. The class with the lower pretest mean score (M = 56.82) was assigned as the experimental group, while the class with a slightly higher mean score (M = 57.11) was designated as the control group.

The sample comprised 35 females and 7 males, aged between 19 and 20 years. All participants were pre-service physics teachers. Although the sample has consisted predominantly of female participants, this composition accurately reflects the current gender distribution in the physics education program. The intervention, instructional materials, and assessment instruments have been designed to be gender-neutral and were implemented equally across all participants. As gender is not a focus of this study, it is not treated as a moderating variable.

However, future research may explore gender-related effects to determine whether the instructional strategy yields differential outcomes. Additionally, the small sample size reflects the actual conditions of microteaching classes, acknowledging that all participants come from a single university. This sample limitation may restrict the generalizability of the findings to other institutions with different contexts. Nevertheless, the results remain relevant as a reference for developing teaching skills among pre-service teachers in similar contexts.

3.2 Data Collection

The data were collected in this study to assess physics teaching skills, including designing lesson plans, opening the lesson, delivering instructional content, and closing the lesson. The instrument used for data collection was a performance assessment sheet specifically designed to evaluate these aspects. Performance assessment was selected because it can measure authentic teaching skills and real competencies of pre-service teachers in tasks that closely simulate real classroom situations, which are not optimally assessed through written tests or multiple-choice evaluations. In addition, this assessment provides a comprehensive picture of the students' ability to apply knowledge, communication skills, and decision-making in an integrated manner. The assessment used a Likert scale ranging from 1 (poor) to 5 (excellent). The main indicators assessed students' performance in designing lesson plans, opening the lesson, delivering instructional content, and closing the lesson. Performance assessment was directed at evaluating the pre-service teachers’ ability in several teaching skill indicators: creating a conducive atmosphere, conducting apperception, giving initial motivation, setting objectives, reviewing prior material, conducting evaluation, and performing reflection and follow-up. This assessment instrument was implemented during the learning process to obtain accurate and objective data. The instrument was validated by 4 experts, with a validity score of 0.97, which was categorized as valid. Therefore, the instrument was used as a data collection tool in this study.

3.3 Implementation

The implementation procedure for the research was conducted using a quasi-experimental design that divided participants into a control group and an experimental group. Each group underwent the same learning process, carried out over one semester in 14 meetings, each lasting 150 minutes. In the initial phase, a pretest was administered to assess students’ initial abilities before treatment. In the second phase, learning was implemented with each group receiving different treatments. The control group used conventional learning strategies, while the experimental group employed integrated e-modules combining cooperative learning and videos.

The e-modules were designed to support microteaching practices aligned with 21st-century teaching competencies. It included structured lesson plans, self-reflection guides, and collaborative activities based on cooperative learning principles. Instructional videos embedded in the e-modules served as modeling tools, presenting effective teaching practices such as building student engagement, managing interaction, and conducting teaching reflections.

The primary objective of using the e-modules was to improve pre-service teachers’ ability to plan, implement, and reflect on lessons in a more interactive, collaborative, and student-centered manner than conventional methods. To prevent information contamination between groups, participants in the experimental and control groups were placed in separate sessions, and interaction was limited during the treatment period. Learning outcomes were assessed using a posttest to measure improvements after treatment. The complete implementation process is illustrated in Figure 1.

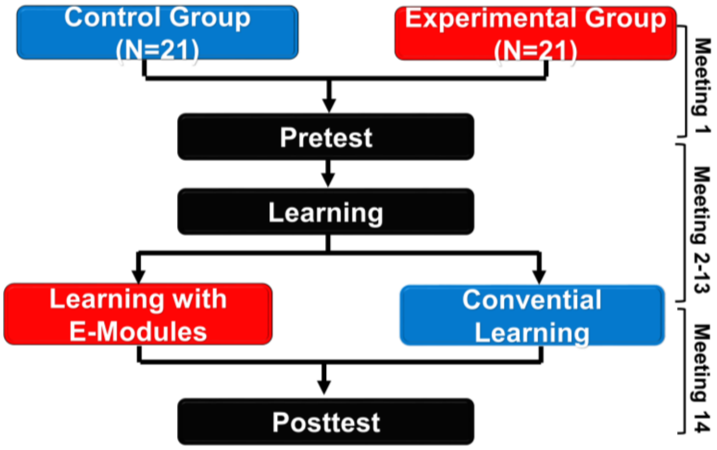

Figure 1: Research implementation procedures

Figure 1 presents the implementation procedure used in the study. The learning data were obtained from pretests and posttests using performance assessment instruments. The pretest was conducted to measure pre-service teachers' initial teaching skills in managing instruction, including opening the lesson, delivering instructional content, and closing the lesson. Both groups engaged in microteaching activities to practice physics teaching skills during the instructional process. Microteaching in this study was part of a teaching skills training program for pre-service physics teachers. It aimed to train and assess teaching competencies through structured simulations in small-scale teaching scenarios.

During microteaching, students were required to design, conduct, and reflect on their teaching practices in front of peers acting as students. Evaluation was conducted by lecturers and peers using a validated rubric. This activity allowed for a systematic assessment of skills such as opening and closing lessons, delivering instructional content, and managing classroom interactions. Learning outcomes were analyzed based on the data collected from pretests and posttests. This analysis aimed to assess improvements in skills between the two groups after implementing different learning strategies.

3.4 Data Analysis

Students' learning outcomes were analyzed statistically using the software Statistical Package for the Social Sciences (SPSS 26). This analysis aimed to determine the extent of the treatment's impact on physics teaching skills. Before inferential analysis, prerequisite tests, including normality and homogeneity, were performed. The normality test was used to verify whether the data were normally distributed, while the homogeneity test assessed the equality of group variances. The data did not meet these assumptions; thus, non-parametric statistical tests were selected.

The statistical tests used in this study included the Wilcoxon test (W test) and the Mann-Whitney test (U test). The W test examined improvements within each group, while the U test compared the effectiveness of the treatments between groups. Test results were interpreted based on p-values and Z-values. If $p < 0.05$ or $Z < -1.96$, the difference in skill enhancement was considered statistically significant. The U test results were further analyzed by calculating effect sizes. Effect size (ES) was calculated using the Z-value and sample size (n) according to Pearson's correlation formula (Equation 1). Effect size interpretation followed Cohen's criteria, with ES = 0.1 representing a small effect, ES = 0.3 a medium effect, ES = 0.5 a large effect, and ES = 1.2 a very large effect (Cohen, 2016).

$$ES = \frac{\dfrac{Z}{\sqrt{n_1 + n_2}}}{\sqrt{1 - \left(\dfrac{Z}{\sqrt{n_1 + n_2}}\right)^2}} \qquad \text{(Equation 1)}$$

4. Results

The data for this study were obtained from the pretests and posttests administered to 42 pre-service physics teachers enrolled in a physics education program. Each participant demonstrated physics teaching skills in the context of designing lesson plans, opening the lesson, delivering instructional content, and closing the lesson. Prerequisite analysis tests were conducted to determine the appropriate type of statistical analysis. The prerequisite tests included the Shapiro–Wilk test for normality and Levene's test for homogeneity, aimed at assessing whether the data were normally distributed and homogeneous. The Shapiro–Wilk test was applied due to its suitability for small sample sizes ($n < 50$). Meanwhile, Levene's test was used to examine homogeneity. These results determined the inferential statistical techniques suitable for analyzing group differences. The results of the normality and homogeneity tests are presented in Table 2.

Table 2: Normality Test and Homogeneity Test

Test	Class	Shapiro-Wilk			Levene Statistic
		Statistic	df	p	p
Pretest	Experimental	0.944	21	0.256	0.558
	Control	0.966	21	0.646	
Postest	Experimental	0.959	21	0.492	0.002
	Control	0.991	21	0.999	

Table 2 presents the results of the normality and homogeneity tests on pretest and posttest data from both groups. The data are considered normally distributed and homogeneous when $p > 0.05$. The pretest results showed that both groups achieved $p > 0.05$ for both normality and homogeneity, indicating normally distributed and homogeneous data. Thus, the students' initial abilities were relatively balanced. In contrast, the posttest results revealed differences. The normality test indicated a $p > 0.05$, confirming normal distribution. However, Levene's test yielded a $p = 0.002$, meaning the data were not homogeneous. Based on these findings, the statistical analysis was adjusted. Therefore, non-parametric tests were employed: the W test for within-group analysis and the U test for between-group comparisons. Both tests were used to evaluate the effectiveness of the integrated e-modules combining cooperative learning and videos compared to conventional instruction.

4.1 The Enhancement of Physics Teaching Skills Among Pre-Service Physics Teachers Through Conventional Learning and E-Modules

Data from both groups were obtained through pretest and posttest results to evaluate the development of teaching skills. The data reflected improvements in both the control and experimental groups. The teaching skill scores were presented as overall averages for each group. Average scores were calculated for both pretest and posttest to assess improvement. The comparison of means is illustrated in Figure 2.

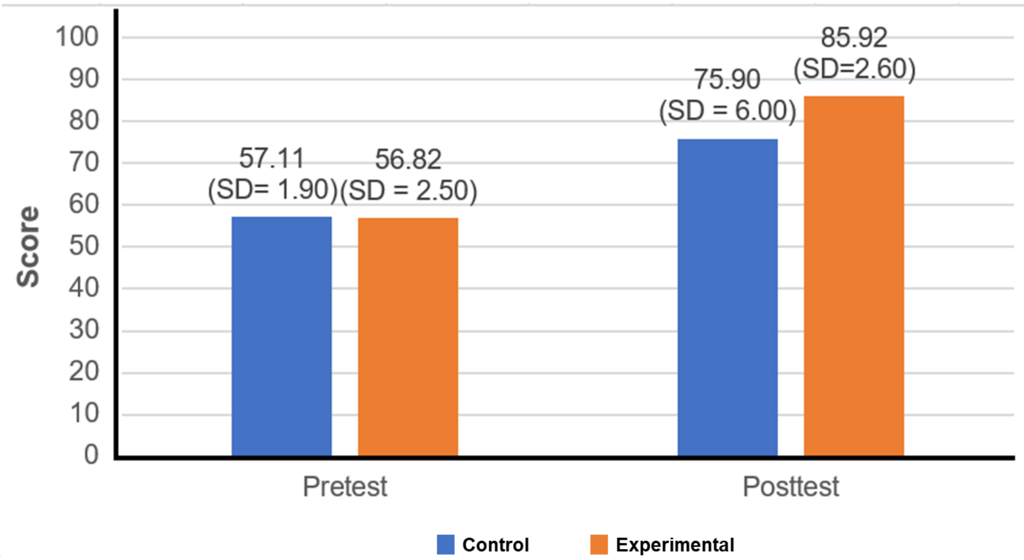

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Figure 2: Pretest and posttest results

Figure 2 shows the skill levels of both groups based on pretest and posttest scores. In the control group (conventional learning), the average pretest score was 57.11 (SD = 1.90), which increased to 75.90 (SD = 6.00) in the posttest. In the experimental group (integrated e-modules), the pretest average was 56.82 (SD = 2.50), and the posttest average rose to 85.92 (SD = 2.60). Although both groups showed improvement, individual progress was further examined using the W test. The results of the W test are presented in Table 3.

Table 3: Wilcoxon Test (W test)

Group (Pretest-Posttest)	Positive Rank	Negative Rank	Ties	Z	p
Control	21	0	0	-4.015	0.000
Experimental	21	0	0	-4.019	0.000

Table 3 presents the results of the W test for both groups. In the control group, there were 21 positive ranks and 0 negative ranks, indicating that all participants experienced improvement through conventional learning. This was supported by a $p < 0.05$. Similarly, the experimental group showed 21 positive and 0 negative ranks, indicating that integrated e-modules learning led to improved teaching skills. This result was also supported by a $p < 0.05$. Therefore, both conventional and integrated e-module strategies contributed to the enhancement of teaching skills.

4.2 The Effectiveness and Effect Size of Learning With Integrated E-Modules Combining Cooperative Learning and Videos in Enhancing the Physics Teaching Skills of Pre-Service Physics Teachers

The results of the W test indicated that both groups experienced an enhancement in physics teaching skills. However, further analysis was needed to determine which strategy was more effective. The U test was utilized to compare the effectiveness of conventional and integrated e-modules of cooperative learning and videos more comprehensively based on the posttest results from both groups. Additionally, effect size analysis was performed to quantify the impact. The results of the U test and effect size calculations are presented in Table 4.

Table 4: Mann-Whitney Test (U Test) and Effect Size

Group	U	P	Z	Effect Size (ES)
Control-Experimental	25.000	0.000	-4.924	2.33

Table 4 presents the U-test and effect size results. The U value was 25.000 with a $p < 0.05$ and $Z = -4.924$, indicating a statistically significant difference. This suggests that the integrated e-modules were more effective than conventional learning. The effect size was found to be 2.33, which falls into the very large category. These findings demonstrate that the integrated e-modules combining cooperative learning and videos had a substantial impact on teaching skill development. Therefore, it is recommended for use in pedagogical training, particularly in designing lesson plans, opening the lesson, delivering instructional content, and closing the lesson.

5. Discussion

5.1 The Enhancement of Physics Teaching Skills Among Pre-Service Physics Teachers Through Conventional Learning and E-Modules

Based on the results of the data analysis, both groups showed a significant increase between the pretest and posttest results. The group using the conventional learning strategy achieved an average posttest score of 75.90 (SD = 6.00), while the group utilizing the integrated e-modules combining cooperative learning and videos achieved an average score of 85.92 (SD = 2.60). Although conventional learning can improve teaching skills, it has limitations in fostering active, collaborative, and reflective engagement, which are essential for 21st-century education.

Therefore, the implementation and testing of innovative learning through the integrated e-modules combining cooperative learning and videos were conducted to compare their direct impact on teaching skills. This study provides strong empirical evidence that the alternative approach is relevant and more effective than conventional methods in specific contexts. These results indicate that the integrated e-modules combining cooperative learning and videos were more effective in enhancing teaching skills, particularly in designing lesson plans, opening the lesson, delivering content material, and closing the lesson. This study presents novelty by focusing on the effectiveness of the integrated e-modules combining cooperative learning and videos in improving essential pedagogical skills for pre-service physics teachers. This finding aligns with previous research, as stated by Chan (2023), who asserts that integrated e-modules of cooperative learning and videos provide a deeper learning experience, accompanied by more detailed explanations, thereby aiding students in better understanding concepts than a conventional learning strategy (Chan et al., 2023).

In addition, the integrated e-modules combining cooperative learning and videos have been shown to enhance pre-service teachers' self-confidence and motivation due to the active interaction and supportive, collaborative learning environment. Teacher training using the integrated e-module of cooperative learning and videos has helped participants understand the stages of designing lesson plans and implementing them more effectively in the teaching process (Legrain et al., 2023). The interactions and feedback provided during the learning process enabled students to complement each other's shortcomings within the group, thereby strengthening their teaching skills (Murphy Odo, 2022).

This result is consistent with previous findings, which indicate that integrated e-modules combining cooperative learning and videos enhance pre-service physics teachers' learning outcomes, motivation, and social skills (Bećirović et al., 2022; Mendo-Lázaro et al., 2022). In Vygotsky's theory of social constructivism, social interaction and group work are regarded as essential components in knowledge construction (Shah, 2022). Through collaboration in small groups, students not only share ideas but also reflect on and reinforce their understanding, which explains why this strategy is superior to more passive, lecture-based methods.

The integration of media in the learning process contributes to the development of communication skills, which are essential for enhancing teaching competence (Louis & King, 2022). Implementing videos as learning media has helped students improve their skills in opening and closing lessons during microteaching (Mäkipää et al., 2022; Sugihartini et al., 2025). Group collaboration has enabled students to design more coherent and effective lesson plans than when working individually (Legrain et al., 2023).

5.2 The Effectiveness and Effect Size of Learning With Integrated E-Modules Combining Cooperative Learning and Videos in Enhancing the Physics Teaching Skills of Pre-Service Physics Teachers

The findings reinforce the conclusion that groups engaged in the integrated e-modules combining cooperative learning and video activities demonstrate deeper understanding and more structured teaching skills in designing lesson plans, opening the lesson, delivering instructional content, and closing the lesson. Furthermore, pre-service physics teachers in these groups participated more actively in discussions, provided feedback, and co-constructed ideas collaboratively. Interactions between groups appear to have supported skill development during microteaching simulations (O'Flaherty et al., 2023). This is in contrast to conventional learning, which often limits collaboration and relies heavily on direct guidance from instructors. Active learning approaches contribute significantly to conceptual understanding and teaching effectiveness (Danday, 2019). Microteaching strategies tailored to teachers’ needs have proven effective in fostering lesson design and implementation skills (Handayani, 2022).

The integrated e-modules of cooperative learning and videos offer a meaningful learning experience by actively engaging pre-service teachers. Through group work, pre-service teachers are encouraged to take responsibility for their own learning and that of their peers. This approach also reinforces conceptual understanding while simultaneously cultivating communication and collaboration skills (Yang, 2023). In addition, the collaborative environment fosters public speaking confidence, active listening, and logical reasoning.

Simulations in the teaching and learning process with peers provide a good understanding of enhancing communication skills. Peer simulations during microteaching have facilitated the development of these skills, leading to improved confidence in expressing instructional ideas (Kartal & Çınar, 2024). In the context of physics education, this approach not only aids comprehension but also equips students with the communication skills necessary for effective science teaching (Legrain et al., 2023).

Overall, this research demonstrates that the integrated e-modules combining cooperative learning and videos are effective for improving content mastery and significantly advancing pre-service physics teachers' teaching skills. The effect size of 2.33 obtained in this study falls into the very large category, exceeding those reported in earlier studies that typically found moderate effects (Aktaş & Özmen, 2022; Fimansyah et al., 2023). Thus, this result strengthens the position of cooperative learning as a highly beneficial instructional strategy for training future physics teachers.

Moreover, this study contributes both theoretically and practically by demonstrating that the integrated e-modules of cooperative learning and videos have broader benefits than previously acknowledged. Whereas earlier studies focused primarily on engagement and discussion, this study extends those insights to show positive impacts on technical teaching competencies, such as designing, opening, delivering, and closing the lesson. These findings offer a foundation for teacher education programs to implement this approach more widely, particularly as part of field-teaching preparation.

For future research, this model should be tested in more diverse educational contexts and with more complex instructional content. Additionally, integrating the e-modules with immersive technologies, such as Augmented Reality (AR), Virtual Reality (VR), and Artificial Intelligence (AI), may enhance their effectiveness. Longitudinal studies are also needed to assess long-term impacts on professional development. Contextual differences, including facilitator expertise and learner readiness, might explain variations in findings across studies. Therefore, this research not only supports existing findings but also opens new avenues for innovation in teacher education.

6. Conclusion

Based on the research findings, both the e-modules combining cooperative learning and videos and the conventional learning strategy enhanced the physics teaching skills of pre-service physics teachers. However, the e-modules combining cooperative learning and videos resulted in significantly greater improvements than the conventional strategy. The effectiveness of the e-modules combining cooperative learning and videos has been reflected in the effect size value, which was categorized as very large, indicating a substantial impact. Therefore, it is recommended that lecturers implement the e-modules combining cooperative learning and videos in teacher education programs, particularly for training pedagogical competencies in pre-service physics teachers.

In addition, this result serves as a basis for higher education policymakers to promote collaborative, active learning strategies that aim to prepare competent pre-service physics teachers. Although this research demonstrates the effectiveness of the e-modules combining cooperative learning and videos, several limitations should be considered. This study focuses solely on the teaching skills of pre-service physics teachers. Future research could broaden its scope to include pre-service science teachers from other disciplines.

Additionally, psychological variables such as self-efficacy, self-confidence, and learning motivation should be explored as supporting factors for the success of cooperative learning. Future research might also investigate the integration of cooperative strategies with emerging technologies such as Augmented Reality (AR), Virtual Reality (VR), and Artificial Intelligence (AI), to create a more adaptive and interactive collaborative learning environment aligned with technological advancements.

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