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Building Teachers' Digital Pedagogical Competence through Web-Based Interactive E-Module Training

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ABSTRACT

Background: requires teachers not only to be able to use technology, but also to design meaningful learning experiences through the pedagogical utilization of digital media. However, in practice, many teachers still use technology only at the operational level and have not optimally developed interactive digital teaching materials. In this context, training in the development of web-based interactive e-modules is essential as a strategy to strengthen teachers' digital pedagogical competence.

Purpose of Study: This study aimed to describe the process of strengthening teachers' digital pedagogical competence through training in the development of web-based interactive e-modules and to identify changes in participants' competence after participating in the training program.

Methods: This study employed a quantitative approach using a one-group pretest-posttest design. The program was conducted in three stages: planning, implementation, and evaluation. The participants consisted of 25 senior high school teachers selected purposively. Data were collected through a digital pedagogical competence questionnaire, observations of the training process, and assessments of the e-module products, and were analyzed descriptively.

Results: The findings revealed an improvement in teachers' digital pedagogical competence, indicated by an increase in the average score from 58.96 in the pre-test to 81.44 in the post-test, with a gain of 22.6 points or an improvement of 38.2%. Competency enhancement was reflected in three main dimensions: digital instructional design, digital collaboration, and reflective and creative competence. The training also encouraged a shift in teachers' orientation from technology users to more adaptive, creative, and reflective digital learning designers.

Keywords
Digital Pedagogical Competence; Teacher Training; E-Module; Web-Based Learning

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Introduction

The development of digital technology has fundamentally transformed the educational landscape. Learning processes are no longer entirely dependent on face-to-face instruction and printed teaching materials, but have shifted toward a more flexible and multimodal learning ecosystem that enables students to learn more independently. However, the digitalization of learning does not automatically guarantee improved educational quality. Recent systematic reviews indicate that digital learning and blended learning have the potential to enhance student engagement and learning outcomes; nevertheless, these impacts largely depend on the quality of instructional design, the types of interactions established, and the relevance of the learning activities provided. In other words, technology becomes meaningful not merely because of its digital nature, but because of its ability to support purposeful, interactive, and pedagogically oriented learning experiences. In this context, web-based learning media represent a relevant innovation because they integrate accessibility, flexibility, and interactivity within a single learning environment (De Bruijn-Smolders & Prinsen, 2024; Jacob & Centofanti, 2024).

Along with these changes, the role of teachers has also shifted. Teachers are no longer expected merely to master the technical use of digital devices or applications, but are required to possess digital pedagogical competence, namely the ability to integrate technology meaningfully into lesson planning, instructional implementation, assessment, feedback, and classroom management. Systematic studies have shown that teachers' digital competence encompasses a broad range of dimensions, including the selection of digital learning resources, material development, learning activity design, digital assessment, and student empowerment within technology-based learning environments. Nevertheless, studies on teachers' digital competence still frequently position teachers only as functional users of tools rather than as instructional designers. In Indonesia, this issue remains evident. Syahid et al. (2022) found that only 53% of teachers used digital devices in every teaching session, 31% used them occasionally, and 16% never used them at all. Furthermore, the dominant forms of technology use were limited to social media (68%) and video conferencing platforms (59%). These findings indicate that teachers' use of technology remains largely operational and has not yet reached the level of digital pedagogical design (Smestad et al., 2023; Kiryakova & Kozhuharova, 2024; Syahid et al., 2022).

A preliminary survey of the 25 participating teachers further revealed that most participants had limited experience in developing web-based interactive learning materials, and the average pre-test score of digital pedagogical competence was 58.96. These findings indicate that teachers still require systematic support to develop competencies not only in operating technology, but also in designing meaningful digital learning experiences.

One learning medium with considerable potential to address these needs is the web-based interactive e-module. Unlike static digital modules, web-based interactive e-modules allow the integration of text, images, videos, animations, hyperlinks, quizzes, and immediate feedback within a single platform accessible through browsers on various devices. This characteristic enables e-modules to function not only as teaching materials, but also as learning spaces that promote interaction, independent practice, and learning progress monitoring. Al Mamun and Lawrie (2023) demonstrated that in online modules requiring self-regulation, the quality of instructional guidance significantly influences students' behavioral engagement. At the national level, Yuliana et al. (2023) reported that interactive e-modules based on Liveworksheets achieved a very high validity level (97.70%) and excellent attractiveness and practicality responses (94.85%). More specifically, Nindiasari et al. (2022) found that interactive e-modules positively affected mathematics teachers' understanding of the Minimum Competency Assessment in numeracy. Nevertheless, Jacob and Centofanti (2024) cautioned that interactivity does not automatically improve learning outcomes when user engagement remains low. Therefore, the quality of scaffolding, accessibility, and learning flow continues to be critical determining factors (Al Mamun & Lawrie, 2023; Yuliana et al., 2023;

Nindiasari et al., 2022; Jacob & Centofanti, 2024).

Another emerging issue is that many teachers and pre-service teachers still lack sufficient experience in developing digital learning media grounded in pedagogical needs. This gap is related not only to technical skills, but also to the ability to translate learning objectives into coherent digital learning experiences. The systematic review conducted by Osorio Vanegas et al. (2025) emphasized that educational technology training for teachers requires integrative mastery involving technological, pedagogical, content, assessment, and professional development dimensions. Meanwhile, Smestad et al. (2023) highlighted that many studies on teachers' digital competence still rely heavily on self-report measures and fail to adequately capture teachers' capacities as instructional designers. Thus, the primary issue is not merely whether teachers are capable of using technology, but whether they are capable of designing meaningful digital learning through technology (Osorio Vanegas et al., 2025; Amemasor et al., 2025; Smestad et al., 2023).

In the Indonesian context, the urgency of training as a strategy for strengthening teacher competence has become increasingly evident. Faldesiani et al. (2025) identified a significant and strong relationship between the effectiveness of education and training programs and the digital competence of vocational high school teachers in Majalengka Regency. These findings indicate that effectively designed training programs play a crucial role in improving teachers' readiness to face the digital transformation of education. This conclusion is reinforced by the study of Triwahyuni et al. (2025), which demonstrated that intensive technology-based training, teacher collaboration, and technology integration into lesson plans improved teachers' abilities to design and implement interactive project-based learning. However, the same study also identified several obstacles, including limited infrastructure, poor internet access, and insufficient training duration. These findings suggest that while training is essential, the training needed should extend beyond mere application introduction and instead provide opportunities for practice, reflection, collaboration, and classroom implementation support (Faldesiani et al., 2025; Triwahyuni et al., 2025).

Based on the foregoing discussion, the novelty of this article lies in positioning teachers as the primary subjects of development rather than merely end-users of digital media. The training in developing web-based interactive e-modules presented in this article is viewed not only as an effort to produce digital teaching materials, but also as a process of strengthening teachers' digital pedagogical competence, instructional design creativity, and professional reflection. This perspective is important because the challenge of digital education today is no longer simply the availability of technological devices, but rather teachers' ability to transform themselves from technology users into designers of digital learning experiences who are aware of instructional goals, contextual conditions, and students' needs. Therefore, this article aims to describe the process of strengthening teachers' digital pedagogical competence through training in the development of web-based interactive e-modules and to identify changes in participants' competence after participating in the training program.

Method

The Web-Based Interactive E-Module Development Training Program was conducted using a quantitative approach with a one-group pretest–posttest design to measure changes in participants' digital pedagogical competence before and after the training intervention. This approach was selected because it is effective in assessing the impact of a training intervention through comparisons between initial and final scores within the same group (Creswell, 2018; Chiu et al., 2024). The participants consisted of 25 senior high school teachers selected purposively based on their active involvement in classroom instruction and readiness to use digital devices. To ensure that the training intervention was implemented systematically and aligned with the objective of strengthening digital pedagogical competence, the program was designed in three main stages: planning, implementation, and evaluation. These stages were interconnected to identify participants' initial conditions, facilitate

practice-based learning processes, and assess measurable changes in participants' competencies after the training program.

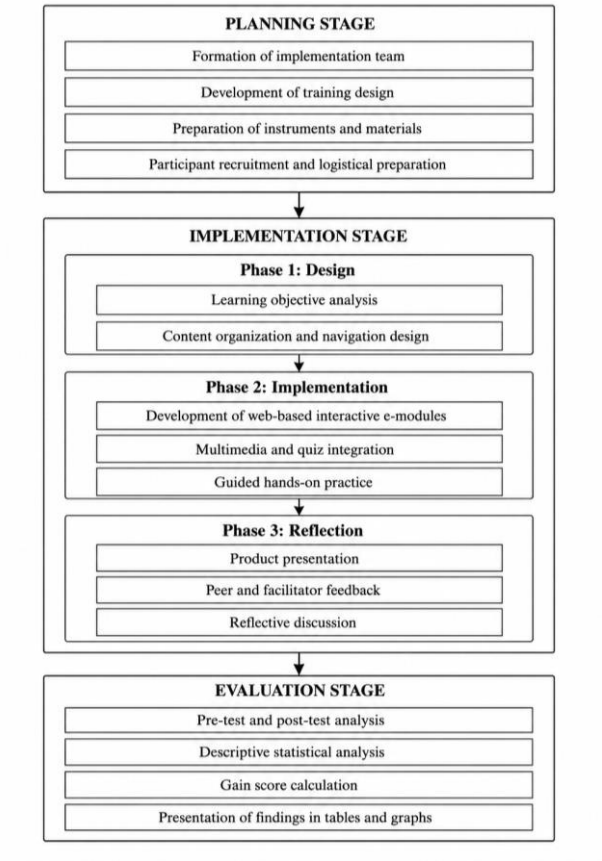

Figure 1. Method Flowchart

Planning Stage

The planning stage involved the establishment of the implementation team, the preparation of the training program design, activity scheduling, and the development of quantitative instruments in the form of a digital pedagogical competence questionnaire. The instrument was developed based on indicators of teachers' digital pedagogical competence, including digital lesson planning, pedagogical integration of technology, design of interactive learning activities and assessments, and reflective use of technology in learning (UNICEF, 2022; Amemasor et al., 2025).

The preparation process was conducted approximately one week prior to the training activities and included participant recruitment, venue determination, preparation of supporting facilities such as laptops and internet access, as well as the finalization of training materials and guidelines for developing web-based interactive e-modules using the Google Sites platform.

Implementation Stage

The implementation stage was conducted in December 2025 over a three-day training program consisting of approximately 24 instructional hours. The training activities combined short lectures, demonstrations, guided discussions, and hands-on practice sessions. Before the training began, participants completed a pre-test to measure their initial level of digital pedagogical competence.

The implementation process was organized into three learning phases: design, implementation, and reflection. In the design phase, participants were guided to analyze learning

objectives, structure e-module content, and develop instructional flow and navigation systems suitable for digital learning environments. In the implementation phase, participants practiced integrating multimedia components such as images, videos, hyperlinks, animations, and interactive quizzes into their e-modules using Google Sites. Participants also developed formative assessments and feedback features aligned with instructional objectives. In the reflection phase, participants presented their e-modules, received peer and facilitator feedback, and reflected on the pedagogical strengths and limitations of their digital learning designs.

At the end of the training program, participants completed a post-test using the same instrument administered during the pre-test stage to measure changes in digital pedagogical competence after the intervention. The hands-on approach accompanied by continuous feedback throughout the training process was intended to ensure the integration of technological mastery with pedagogical considerations in digital instructional design (Skrbinjek et al., 2024).

Evaluation Stage

The evaluation stage focused on quantitative analysis of the pre-test and post-test results as indicators of participants strengthened digital pedagogical competence. The data were analyzed using descriptive statistics, including minimum score, maximum score, mean score, and percentage improvement in digital pedagogical competence. In addition, the difference between pre-test and post-test scores (gain score) was used to describe the level of competency improvement achieved after participation in the training program (Creswell, 2018; Osorio Vanegas et al., 2025).

Data analysis was conducted using Microsoft Excel, and the results were presented in the form of tables and graphs to illustrate trends in the improvement of teachers' digital pedagogical competence following the web-based interactive e-module development training.

Result

Overview of the Training Program and Changes in Participants' Orientation

The web-based interactive e-module development training program was attended by 25 senior high school teachers. The training was designed using a hands-on training and collaborative mentoring approach. The focus of the program was not merely on tool mastery, but also on the pedagogical reasoning and reflective processes underlying each instructional design decision. During the initial sessions, teachers demonstrated limited understanding of technology integration within pedagogical contexts. Pre-observation findings indicated that most participants still perceived e-modules as substitutes for printed textbooks or PowerPoint presentations rather than as interactive learning instruments. To address this issue, the facilitators introduced the Educators' Digital Competency Framework (UNICEF, 2022) to help participants understand the five domains of teachers' digital competence: knowledge development, knowledge application, knowledge sharing, knowledge communication, and ethical use.

These initial discussions fostered new awareness among participants, encouraging teachers to re-evaluate their own teaching experiences. Several participants stated in their reflections that they had only recently realized the importance of designing e-modules that are not merely informative, but also capable of guiding students to think critically and interact actively during the learning process. This finding indicates the initial stage of an orientation shift, from a predominantly technical focus toward a deeper awareness of digital pedagogy.

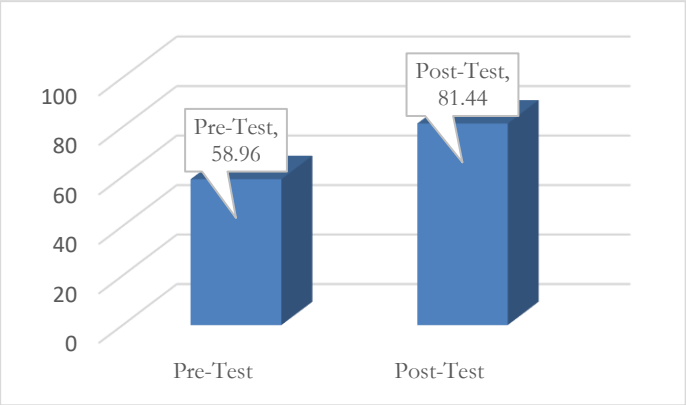

Figure 2. Training Effectiveness

Table 1. Descriptive Statistics

Statistics	Pre-Test	Post-Test
Mean	58,96	81,44
Minimum	54	75
Maximum	64	88
Mean Gain Score	-	22,6
Percentage of Improvement	-	38,2%

The training program was conducted over three days with a total duration of approximately 24 instructional hours. Participant attendance reached 96%, indicating a high level of engagement throughout the training process. Each phase of the training lasted approximately eight instructional hours, including guided practice, mentoring, discussion, and reflection sessions. Descriptive statistical analysis showed an improvement in teachers' digital pedagogical competence after participation in the training program. The mean pre-test score of 58.96 increased to 81.44 in the post-test, with an average gain score of 22.6 points. The percentage increase in digital pedagogical competence reached 38.2%, indicating that the training program positively contributed to strengthening teachers' digital pedagogical competence.

Learning Process During the Training Program

The core training activities were conducted through three interconnected phases: (a) content structure design, (b) interactive design implementation, and (c) product reflection. During the design phase, participants developed learning objectives, content maps, learning activities, and formative assessment strategies. Observational findings indicated that teachers began to connect instructional objectives with concrete learning activities.

The interactive design implementation phase required participants to engage in design thinking processes. Teachers experimented with Google Sites to create page layouts, organize navigation systems, and integrate videos, quizzes, and learning resource links into their e-modules. During this phase, differences in participants' digital skills became evident. Teachers who were already familiar with digital technologies adapted more quickly, while others experienced technical difficulties. However, through peer mentoring, more experienced participants assisted their colleagues in overcoming these challenges. This process fostered a peer learning culture that strengthened both social and digital competencies among participants.

The product reflection phase demonstrated significant progress. Participants presented the e-modules they had developed and discussed the pedagogical rationale underlying their design

decisions. For instance, one participant explained that the placement of a video at the beginning of the module was intended to function as a "cognitive activator" to provide students with contextual understanding before reading the main material. Such explanations indicate that teachers had begun to think pedagogically within digital environments by connecting technological features with intended learning outcomes.

1. Technical Stage: Teachers Learned to Use Digital Platforms.

The first layer of improvement was observed in the technical domain, where teachers began to master the use of digital platforms as a fundamental prerequisite for developing web-based e-modules. Progress at this stage was reflected in participants' ability to organize page structures more systematically, manage menu hierarchies, and create navigation systems that facilitated users' movement between sections. Teachers who initially experienced difficulties with operational tasks—such as creating pages, embedding videos, linking learning resources, or integrating quizzes—gradually became more independent in managing these features.

As technical barriers diminished, participants' focus also began to shift. They were no longer primarily concerned with "how to install features," but increasingly considered "which features are most appropriate" for the instructional objectives and learning contexts being designed. This shift indicates that participants' technological understanding was gradually becoming more pedagogically oriented.

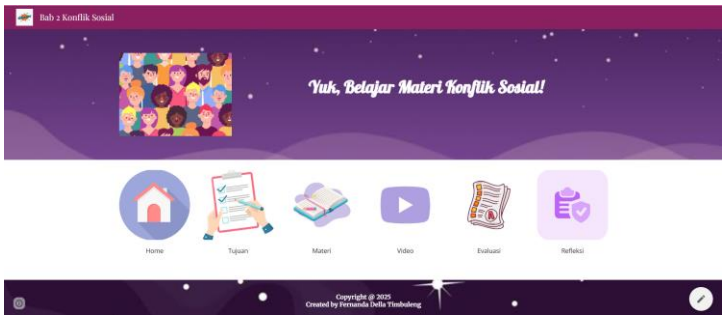

Figure 3. E-Modules Developed by the Training Participants

2. Reflective Stage: Teachers Understood the Pedagogical Rationale Behind the Design.

The second layer of development emerged within the reflective domain, where teachers not only became capable of using digital features but also began to understand the pedagogical rationale underlying their e-module design decisions. Interviews and reflective discussions conducted during the mentoring process revealed changes in the ways participants explained their instructional choices. For example, the placement of videos was no longer viewed merely as decorative elements or visual variations, but rather as initial stimuli intended to establish contextual understanding before students engaged with the main learning materials. Similarly, the sequencing of pages began to follow learning pathways rather than simply reflecting the order of content presentation.

Teachers also demonstrated greater awareness of the alignment among learning objectives, activities, and assessment. When instructional objectives required students to analyze or apply concepts, participants were encouraged to develop learning tasks that demanded higher-order thinking processes rather than relying solely on memory-based quizzes. In this process, instructional directions within the e-modules became more operational and supportive of student learning, as teachers increasingly considered what students should do after reading materials, watching videos, or completing exercises, including how students could obtain feedback to improve their understanding

3. Transformational Stage: Teachers Connected the Training Experience with Their Classroom Practices.

The third layer was observed at the transformational stage, where participants began to directly relate their training experiences to their own classroom teaching practices. At this stage, teachers no longer viewed e-modules merely as products to be developed, but also considered how these e-modules could realistically be implemented in authentic learning situations. Participants connected their e-module designs with classroom conditions and student characteristics by considering factors such as limited access to devices and internet connectivity, adjusting multimedia usage to reduce technical burdens, and designing collaborative activities for students who did not possess personal digital devices.

In addition, a shift in teachers' perspectives regarding their professional roles became evident. Teachers increasingly positioned themselves as designers of digital learning experiences rather than solely as content deliverers. Interview findings demonstrated that participants began to critically re-evaluate their teaching habits and consider how e-modules could support students in becoming more active, independent, and engaged learners. Therefore, the improvements observed in this training program extended beyond technological skills and encompassed teachers' pedagogical reasoning and their readiness to implement digital learning practices within real classroom contexts.

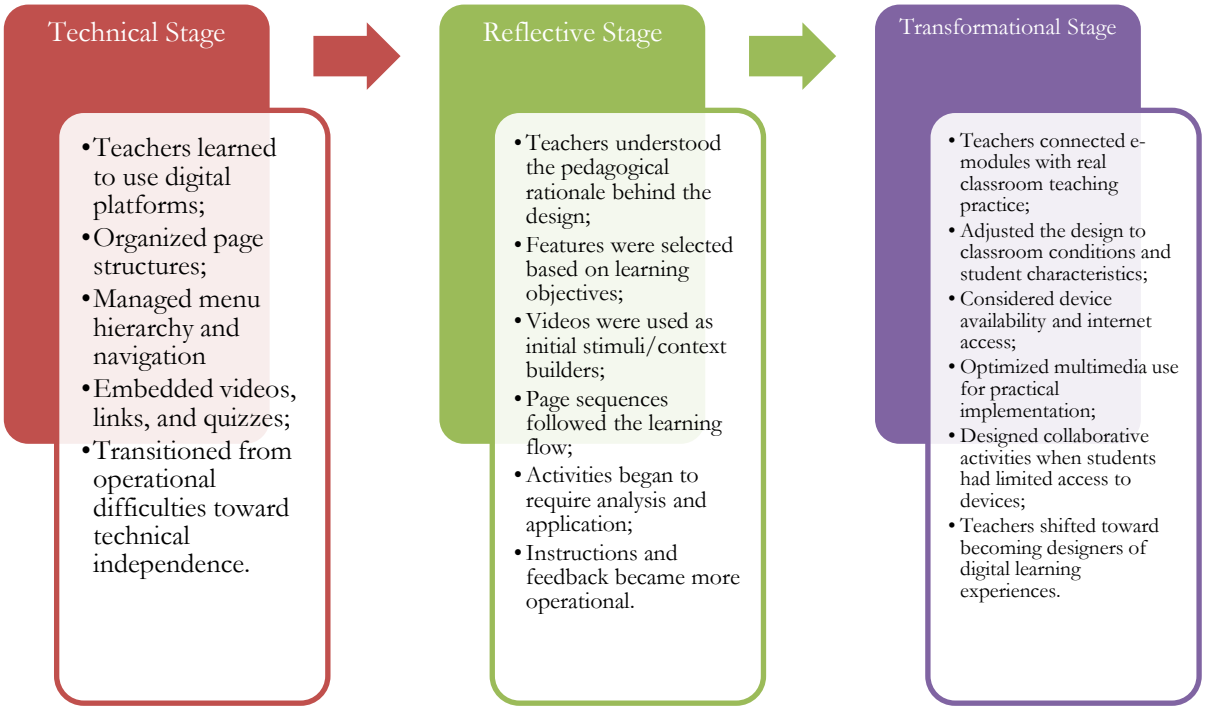

Figure 4. Development of Teachers' Digital Pedagogical Competence During the Web-Based E-Module Training

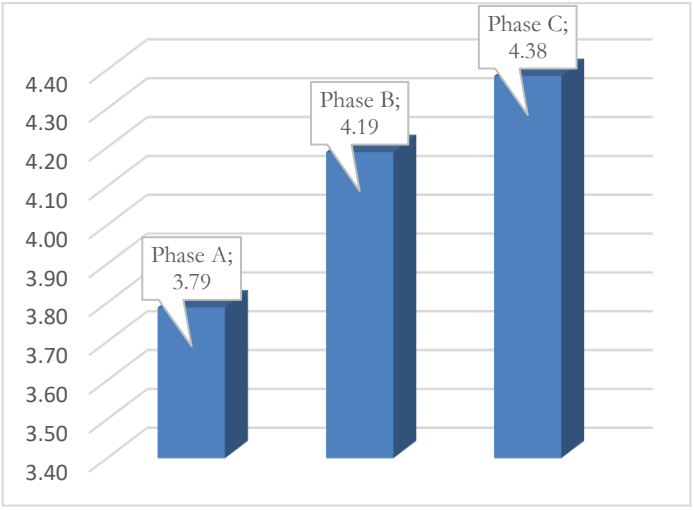

Figure 5. Results of the Learning Process During the Training Program

The analysis of the learning process during the training program demonstrated that the activities progressed systematically through three major phases. In the content structure design phase, the average score of 3.79 indicated that participants were able to formulate instructional objectives, organize content sequences, and design digital learning activities within a good category. Improvement was observed in the interactive design implementation phase, which achieved an average score of 4.19, indicating participants' proficiency in utilizing the Google Sites platform and integrating multimedia components effectively. The highest score was obtained in the product reflection phase, with an average score of 4.38, demonstrating that participants were not only capable of developing e-modules, but also able to explain their pedagogical rationale and plan their implementation in classroom learning contexts.

Evidence of Strengthening Digital Pedagogical Competence

In the previous subsection, the strengthening process was reflected through the dynamics of participants' learning experiences during the training program. In this section, evidence of competency strengthening is described more specifically through changes in the quality of the e-module products, participants' pedagogical arguments during presentations, and their ability to revise instructional designs after receiving feedback. Therefore, the strengthening of competence in this program was reflected not only in quantitative score improvements, but also in changes in how teachers understood, designed, and interpreted technology as part of instructional strategies. The strengthening of digital pedagogical competence was observed in three major dimensions.

1. Digital Instructional Design Competence

Strengthening within this dimension became evident when participants no longer developed e-modules merely as collections of digital materials, but instead began designing comprehensive and structured learning pathways aligned with instructional objectives. Most of the resulting products demonstrated more systematic structures, including introductory sections functioning as stimuli or apperception activities, core sections for concept exploration and learning activities, and concluding sections containing reflection or formative assessment components. This development was important because, at the beginning of the training program, several participants still tended to transfer printed materials or presentation slides directly into web formats without considering students' overall learning experiences.

Following the mentoring process, participants increasingly aligned instructional objectives, learning activities, and assessments within more coherent instructional designs. Some teachers even demonstrated the application of backward design principles by determining learning objectives and evidence of learning achievement before selecting instructional materials and activities. These findings indicate that the training program not only improved participants' technical skills in using digital platforms, but also encouraged a shift in orientation from content delivery toward the design of meaningful digital learning experiences.

Nevertheless, the quality of instructional design was not entirely uniform across participants. In several e-modules, greater emphasis remained on content presentation rather than on the provision of scaffolding, feedback mechanisms, and differentiated learning activities. This finding suggests that future competency strengthening efforts should focus more extensively on adaptive instructional design so that the resulting e-modules become not only structurally organized, but also more responsive to students' diverse learning needs.

2. Digital Collaboration Competence

The dimension of digital collaboration developed not only as a form of technical cooperation among participants, but also as a professional dialogue space concerning pedagogical decisions in e-module design. Throughout the training program, participants shared learning resources, design templates, multimedia integration techniques, and strategies for overcoming challenges in using Google Sites. These interactions helped reduce disparities in participants' initial competencies, particularly among teachers who had limited experience with web-based platforms. Through peer support, technical barriers that initially had the potential to hinder the learning process were gradually resolved through naturally occurring peer mentoring mechanisms.

This collaborative process evolved from technical assistance into more substantive pedagogical discussions. Feedback exchanged among participants no longer focused solely on "how to install features," but also addressed more pedagogical concerns, such as whether navigation systems facilitated student learning effectively, whether selected videos were relevant to instructional objectives, and whether quizzes appropriately measured students' understanding. In this context, digital collaboration functioned as a social learning mechanism that accelerated the transfer of best practices while enriching the quality of instructional decision-making.

These findings are consistent with Amemasor et al. (2025), who emphasized that teacher professional development in the digital era becomes more effective when supported by collaborative work and learning communities. However, the collaboration established in this program remained largely situational and limited to the duration of the training activities. To ensure sustainability, schools need to facilitate communities of practice or regular sharing forums so that cultures of collaborative learning and constructive feedback can continue beyond the completion of the training program.

3. Reflective and Creative Competence

The reflective and creative dimension provided the strongest evidence that the training program extended beyond the mere mastery of digital features. Participants began to demonstrate creativity grounded in instructional needs and subject-specific characteristics. For example, science teachers utilized simulations and experimental videos to substitute laboratory experiences that could not always be conducted directly. Social studies teachers integrated digital maps as tools for social and spatial exploration, while Indonesian language teachers designed reflective writing activities using online forms to expand students' interaction with learning materials. These variations indicate that participants had begun to utilize technology contextually rather than uniformly.

The creativity demonstrated by participants was reflected not only in visual variation, but also in their ability to explain the pedagogical rationale behind selected features. Videos were no longer included merely to make modules appear attractive, but were used as contextual triggers to activate prior knowledge. Quizzes were not simply supplementary components, but increasingly functioned as feedback mechanisms, while navigation systems were designed not solely for aesthetic purposes but also to facilitate students' learning pathways. These findings indicate the emergence of pedagogical reflection, as teachers no longer focused only on "what features can be used," but also on "why these features are selected" and "how these features support student learning."

This condition aligns with Skrbinjek et al. (2024), who argued that teacher creativity in digital training environments develops through interactions among experimentation, reflection, and innovative training support. Nevertheless, the depth of reflection and creativity varied among participants. Some products demonstrated highly meaningful technology integration, whereas others remained predominantly focused on visual presentation aspects. Therefore, future strengthening efforts should aim to develop digital creativity into more pedagogically oriented creativity that prioritizes student learning processes rather than merely media aesthetics.

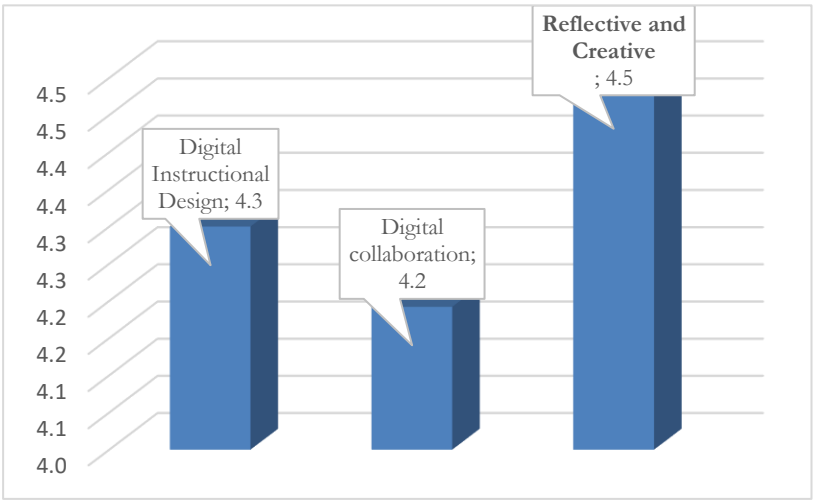

Figure 6. Results of the Strengthening of Pedagogical Competence

Evidence of the strengthening of teachers' digital pedagogical competence after participating in the training program was demonstrated through three major dimensions. Digital instructional design competence achieved an average score of 4.32, categorized as very high, indicating teachers' ability to design e-modules with logical learning sequences aligned with backward design principles. Digital collaboration competence obtained an average score of 4.22, reflecting the establishment of effective peer interaction in sharing resources and providing constructive feedback. Meanwhile, reflective and creative competence achieved the highest average score of 4.51, indicating that teachers were not only capable of using technology, but were also able to apply it reflectively and innovatively according to their respective instructional contexts.

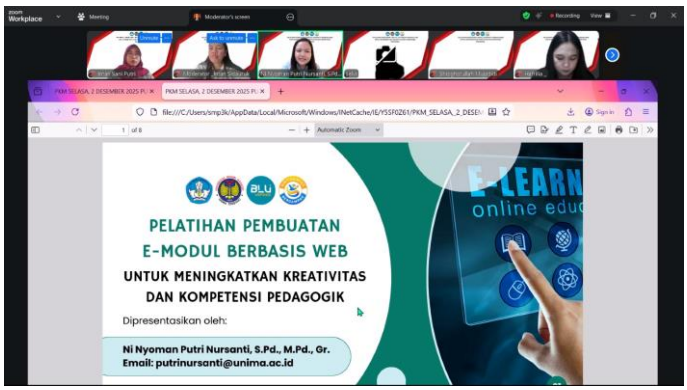

Figure 7. Results of the Training Activity Implementation

Overall, the evidence of strengthening digital pedagogical competence across these three dimensions demonstrates that the training program produced multilayered changes, progressing from technical mastery to pedagogical reasoning and ultimately toward readiness for implementation in authentic learning contexts. These findings are important because they indicate that the success of the training program should not be evaluated solely based on the attractiveness of the final products, but also on the extent to which participants are able to explain the rationale behind their instructional designs, accept feedback, and make conscious revisions and improvements.

Therefore, the outcomes of this program should be understood not merely as the successful production of web-based interactive e-modules, but also as a process of developing teachers into designers of digital learning experiences. Nevertheless, because the current evidence remains focused primarily on the training stage, further investigation is still needed during classroom implementation to examine the sustainability of e-module usage, students' responses, and its impact on the quality of learning.

Discussion

The findings of this study indicate that the web-based interactive e-module training program not only resulted in improvements in quantitative scores, but also promoted a shift in teachers' pedagogical orientation in interpreting the role of technology in learning. The increase in the mean score from 58.96 in the pre-test to 81.44 in the post-test, with a gain score of 22.6 points and an improvement percentage of 38.2%, suggests that participants moved beyond merely mastering digital features operationally and began to use technology in ways that were more consciously aligned with instructional objectives. In the context of teacher professional development, this shift is important because digital pedagogical competence should not be understood merely as the ability to operate applications, but rather as the capacity to connect technology meaningfully with instructional objectives, learning activities, interactions, and assessment processes. These findings are consistent with the study of Amemasor et al. (2025), which emphasized that effective professional training for digital integration is generally collaborative, practice-based, supported by mentoring, and contextualized to instructional needs. In the Indonesian context, these findings are also aligned with Faldesiani et al. (2025), who reported a significant relationship between the effectiveness of education and training programs and improvements in teachers' digital competence. However, these findings should still be interpreted cautiously. Since this study employed only a one-group pretest–posttest design and descriptive analysis, the results should be considered preliminary evidence that the training was beneficial rather than definitive proof of causal relationships. Therefore, future studies should involve comparison groups, stronger statistical analyses, and classroom implementation observations to enhance the validity of the findings.

A closer examination suggests that these changes did not occur instantly, but rather developed through a gradual and structured training mechanism. This pattern is reflected in the progressive increase in scores across the training phases, namely the content structure design phase (3.79), the interactive design implementation phase (4.19), and the product reflection phase (4.38). These results indicate that teachers' learning progressed systematically, beginning with content organization, advancing toward technical implementation, and eventually reaching reflective consideration of the pedagogical rationale underlying the designs they created. Theoretically, this finding is important because it responds to the criticism raised by Smestad et al. (2023), who argued that many studies on teachers' digital competence still position teachers primarily as functional users of technology rather than as instructional designers. In this study, teachers demonstrated a transition from being merely "platform operators" to becoming "designers of digital learning experiences." This shift is also consistent with the systematic review by Osorio Vanegas et al. (2025), which emphasized that educational technology training for teachers should integrate competencies related to software usage, educational applications, virtual collaboration, and comprehensive training models. Therefore, the primary strength of this training program lies not merely in introducing Google Sites as a digital tool, but in creating a learning environment that allowed teachers to design, experiment, evaluate, and revise their instructional products.

Within the dimension of digital instructional design, the mean score of 4.32 indicates substantial improvement in participants' ability to develop e-modules that were more systematic, logical, and aligned with instructional objectives. The findings revealed that most participants no longer simply transferred printed materials or presentation slides into web-based formats, but instead began constructing learning sequences that included apperception activities, concept exploration, learning tasks, and formative assessments. From a pedagogical perspective, this development is highly significant because the quality of digital learning depends largely on the quality of instructional design rather than merely on the presence of interactive features. Jacob and Centofanti (2024) demonstrated that interactive learning resources can improve learning outcomes when they are pedagogically designed and effectively integrated into online learning experiences. Similarly, Al Mamun and Lawrie (2023) emphasized that the quality of instructional guidance and scaffolding within online modules significantly influences students' behavioral engagement. At the national level, Yuliana et al. (2023) and Nindiasari et al. (2022) also reported that interactive e-modules are considered highly valid, practical, and positively influential on users' understanding. Nevertheless, this study also revealed aspects requiring critical attention. Several participants' e-modules remained more focused on content presentation and visual appearance than on differentiated learning pathways, formative feedback, and support for independent learning. Thus, while the progress achieved is promising, further strengthening efforts should focus on adaptive instructional design, feedback loops, and accessibility principles so that e-modules become not only visually attractive, but also capable of facilitating deeper learning processes.

In the dimension of digital collaboration, the mean score of 4.22 demonstrates that learning during the training program developed not individually, but through professional interaction among teachers. This finding is important because it indicates that peer mentoring was not merely a by-product of group activities, but rather a central mechanism in strengthening competence. Teachers with stronger digital skills helped their colleagues overcome technical challenges, while discussions gradually evolved from operational concerns toward pedagogical considerations, such as the relevance of videos, the function of quizzes, and the accessibility of navigation systems for students. This pattern aligns with the study by Liu et al. (2024), which found that professional learning communities mediate the relationship between digital professional development and digital instructional integration. In other words, digital training becomes more effective when supported by active professional learning communities. These findings are also consistent with Triwahyuni et al. (2025), who reported that teacher collaboration, technology-based training, and technical support contribute positively to the development of teachers' digital competence despite existing

infrastructural and time-related challenges. The practical implication is clear: if schools wish to sustain the impact of training programs, collaborative practices that emerge during training must be institutionalized through regular sharing forums, lesson study activities, e-module design clinics, or communities of practice that enable teachers to continue exchanging feedback after the training concludes. Without such follow-up mechanisms, collaboration risks remaining only a temporary workshop experience.

The highest score was obtained in the reflective and creative dimension (4.51), which represents one of the most significant findings of this study. The high score in this dimension indicates that participants were not only able to develop digital products, but also capable of constructing pedagogical arguments for the design decisions they made. This was evident when teachers selected videos, quizzes, hyperlinks, and navigation systems not merely because they were "interesting," but because these features were considered capable of activating contextual understanding, providing practice opportunities, guiding learning pathways, or helping students understand materials progressively. These findings demonstrate the emergence of pedagogical reflection regarding technology use, which contemporary literature considers a fundamental component of transforming digitally mediated teaching practices. Skrbinjek et al. (2024) reported that innovative training models emphasizing experimentation, reflection, collaboration, and collective knowledge creation can simultaneously enhance teachers' creativity and digital pedagogical competence. Similarly, Chiu et al. (2024) emphasized the importance of supportive learning environments and teachers' psychological needs in developing deeper digital competence. However, the high score in this dimension should still be interpreted carefully. Creativity demonstrated within the training context may not automatically translate into sustainable instructional innovation in classroom practice. Some products still showed stronger emphasis on visual aesthetics than on the quality of learning interaction. Therefore, the most appropriate conclusion from this study is not that teachers have fully "mastered" digital pedagogy, but rather that they have begun developing reflective agency as designers of digital learning experiences.

Conceptually, this study contributes by positioning training programs not merely as media production processes, but as processes of developing teachers into digital learning designers. This perspective is important because many previous studies still evaluate training success based primarily on the quality of final products or teachers' perceptions of their digital abilities. As noted by Smestad et al. (2023), research on teachers' digital competence frequently relies heavily on self-report data and often fails to adequately capture teachers' instructional design capacities. In this study, the use of pre-test and post-test data, process observations, product presentations, and participant reflections enriched the analysis by demonstrating that digital pedagogical competence develops through layered experiences encompassing technical, social, reflective, and contextual dimensions. Nevertheless, this study still has methodological limitations. To strengthen the evidence base, future studies should incorporate product rubric reliability testing, inter-rater assessment, effect size or N-gain analysis, as well as follow-up observations several weeks or months after the training program to examine whether the e-modules are actually implemented in classrooms and how students respond to them. In this way, evaluation can move beyond the question of "whether teachers can create e-modules" toward examining "whether the e-modules improve the quality of learning."

From a practical perspective, the findings of this study lead to three major recommendations. First, similar training programs should be designed as sustainable professional development initiatives rather than one-time workshops, followed by classroom implementation mentoring, product revision clinics, and forums for sharing best practices. Second, schools need to strengthen institutional support by providing collaborative time, stable internet access, adequate technological devices, and policies encouraging the use of e-modules in learning activities. This recommendation is particularly relevant because Amemasor et al. (2025) emphasized the importance of ongoing mentoring and institutional support, while Chiu et al. (2024) demonstrated that supportive school learning environments contribute significantly to the development of teachers' digital competence.

Third, future evaluations should extend to examining impacts on student engagement and learning outcomes, because the quality of digital pedagogy is ultimately measured not by the sophistication of the media itself, but by the extent to which it improves students' learning experiences. Therefore, the web-based interactive e-module training program examined in this study can be understood as a strong initial step that still requires systemic reinforcement to ensure that the transformation of teachers' digital pedagogical competence becomes sustainable and produces meaningful impacts on authentic classroom practices.

Conclusion

The web-based interactive e-module training program conducted in this study demonstrates that teachers' digital pedagogical competence can be strengthened not only through improvements in pre-test and post-test scores, but also through changes in teachers' perspectives on technology as an integral part of meaningful learning strategies. These findings emphasize that community service programs based on digital training should not be understood merely as technical skill transfer activities, but rather as processes of professional empowerment that encourage teachers to become more adaptive, creative, reflective, and capable of designing student-centered learning experiences. From a theoretical perspective, the findings reinforce the view that digital pedagogical competence develops through practical experience, collaboration, and reflective processes. From a social perspective, this program has the potential to foster a culture of instructional innovation and professional collaboration within schools. Therefore, future community service programs should be designed more sustainably through classroom implementation mentoring, forums for sharing best practices, and strengthened institutional support from schools. Such efforts are important to ensure that the outcomes of the training program extend beyond the production of e-modules and are genuinely implemented in daily teaching practices. Future studies should also investigate the use of e-modules in classroom settings, students' responses to their implementation, and their impact on learning outcomes. In this way, the training model presented in this study may be further developed into a more comprehensive community service approach for strengthening teachers' digital pedagogical transformation.

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Conflicts of Interest

The authors declare that there are no conflicts of interest related to this study and the writing of this article. All processes related to program implementation, data collection, analysis, and presentation of findings were conducted objectively in accordance with academic purposes and the development of digital learning practices.

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