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Research article

Enhancing lecturer awareness of technology integration within the TPACK framework: A mixed methods study

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Abstract: The integration of technology into higher education has become increasingly important, yet many lecturers lack the necessary skills to effectively incorporate technology into their teaching practices. This study aimed to develop, implement, and evaluate an in-service training program to enhance university lecturers' awareness and skills in technology integration within the Technological Pedagogical Content Knowledge (TPACK) framework. A mixed-methods approach was employed, involving four university lecturers from the Faculty of Education at Amasya University. The study included a needs assessment, pre- and post-tests, and semi-structured interviews. A tailored in-service training program was developed based on the TPACK models and participants' needs. Quantitative results showed an improvement in participants' knowledge of technology integration, with mean scores increasing from 13.75 to 17.25. Qualitative data revealed an enhanced understanding of technology integration, increased confidence in using various technological platforms, and a positive reception of the TPACK model. Participants appreciated the hands-on, collaborative nature of the training program. This study demonstrated the effectiveness of a well-designed, participant-informed in-service training program for enhancing lecturers' technology integration skills within the TPACK framework. The findings highlight the importance of addressing lecturers' specific needs and providing practical, hands-on experiences in technology integration training. Higher education institutions should consider implementing similar training programs to support faculty in developing essential technology integration skills, ultimately contributing to the preparation of future teachers who can leverage technology effectively in their classrooms.

Keywords: technology integration, TPACK, lecturers, mixed methods study, Türkiye

1. Introduction

The rapid advancement of digital technologies has profoundly transformed the teaching and learning process in higher education. Educational technology has evolved from simple audiovisual aids to complex, interactive systems that support personalized learning experiences [1]. This shift has necessitated a reevaluation of traditional pedagogical approaches and the development of new frameworks for effective instruction, particularly in higher education settings [2]. The integration of technology into education extends beyond the mere presence of devices in classrooms; it involves the strategic implementation of digital tools and resources to enhance pedagogical practices and achieve specific learning outcomes [3]. Recent meta-analyses have demonstrated that well-implemented educational technology can significantly improve student achievement across various subjects and grade levels [4,5]. Particularly, technology integration has been shown to support the development of 21st-century skills such as critical thinking, collaboration, and digital literacy [6]. These skills are crucial for success in the global knowledge economy, where adaptability and technological fluency are highly valued.

Technology integration can be defined as the strategic use of digital resources to enhance teaching and learning [2]. While early definitions often focused on the mere presence of technology in classrooms [7], contemporary understandings emphasize the dynamic interplay between technology, pedagogy, and content knowledge. The focus is not solely on the technology itself but on how it supports and transforms pedagogical practices, enriches learning experiences, and fosters the development of 21st-century skills such as critical thinking, collaboration, and digital literacy [8–10]. Recent advancements in educational technology, such as artificial intelligence (AI), machine learning, and immersive learning environments (e.g., virtual and augmented reality), have further expanded the scope of technology integration. These innovations have introduced new possibilities for personalized learning, real-time feedback, and adaptive instruction, which were not fully realized in the early 2000 s [1,5]. As such, technology integration today is not just about using digital tools but also about leveraging these tools to create more engaging, inclusive, and effective learning environments that respond to the diverse needs of students in a rapidly changing digital landscape.

The focus is not solely on the technology itself but on how it supports pedagogy and enriches learning experiences [8]. Effective technology integration aligns with curriculum goals and addresses students' needs by fostering engagement and deep understanding [10]. Studies have suggested that technology enhances active learning, increases motivation, and enables differentiated instruction, which can accommodate diverse learning styles [11]. However, the challenge lies in ensuring that technology is used in a way that complements rather than replaces effective teaching practices. Research has revealed that merely providing access to technology does not guarantee improved learning outcomes, and the effectiveness of technology integration depends on various factors, including teacher preparation, institutional support, and the alignment of technology use with curriculum goals [12]. Moreover, researchers have also highlighted the need to address the potential negative impacts of technology use, such as issues related to screen time, privacy concerns, and the digital divide [13]. To have a meaningful impact, technology must be thoughtfully integrated into lesson plans, assessments, and classroom interactions [14]. This highlights the need for a clear framework to guide educators in effectively leveraging technology, such as the Technological Pedagogical Content Knowledge (TPACK) model [8,9,15].

The TPACK model provides a comprehensive framework for understanding the relationship between technology, pedagogy, and content knowledge in educational settings. This model emphasizes the importance of integrating these three knowledge domains to create effective teaching strategies. The model posits that teachers must understand not only the content they are teaching but also the pedagogical approaches that best convey that content and the technological tools that enhance learning experiences [15]. The strength of the TPACK model lies in its flexibility, as it allows educators to adapt their teaching strategies according to specific subject matter and available technology. For instance, in science education, technology can be used to simulate complex processes or provide interactive experiences that would be difficult to replicate in a traditional classroom. Similarly, in language learning, technology can facilitate immersive experiences and provide real-time feedback to learners.

The TPACK framework has also been widely studied and applied in various educational contexts, particularly in Western countries, where it has been shown to enhance teachers' ability to integrate technology into their teaching practices [16,17]. However, its relevance and effectiveness are not limited to these contexts. In addition to studies conducted in Western contexts, research from countries with similar socio-economic conditions, such as Ghana, has also demonstrated the effectiveness of TPACK-based training programs. For instance, Agyei and Voogt [18] found that a TPACK-focused professional development program significantly improved mathematics teachers' ability to integrate technology in Ghanaian schools. Similarly, studies in other developing countries have highlighted the importance of contextualizing TPACK training to address local challenges, such as limited access to technology and varying levels of digital literacy among educators [19]. These findings underscore the flexibility of the TPACK framework and its potential to be adapted to diverse educational settings, including those with limited resources.

The TPACK framework is particularly relevant for university lecturers, who are increasingly expected to incorporate technology into their teaching [14]. However, many lecturers face significant challenges in this regard [20,21]. Studies have revealed that although university lecturers may have strong content expertise, they often lack the pedagogical and technological knowledge necessary for effective technology integration [2,14,20,21]. For instance, research conducted by Gisbert Cervera and Lázaro Cantabrana [22] found that lecturers who received training in the TPACK model were better able to integrate technology into their teaching, leading to improved student engagement and learning outcomes. Furthermore, studies have indicated that technology can enhance various aspects of higher education, from improving access to resources to facilitating collaborative learning. In a systematic review, Rasheed et al. [13] found that technology integration in higher education enhances student engagement with course materials and facilitates peer collaboration. Despite these benefits, many higher education institutions face challenges in providing adequate training and support for lecturers in effectively using technology in their courses [17].

One of the primary barriers to effective technology integration in higher education is the lack of adequate professional development for university lecturers [14,20,21]. Many lecturers feel unprepared to use technology in their teaching, either because of a lack of training or because they are unfamiliar with how to integrate technology meaningfully into their lessons [9]. Without the necessary support, lecturers may struggle to keep up with rapid technological changes, leading to ineffective or superficial use of digital tools [10]. Additionally, successful integration of technology often requires a shift in teaching practices. Traditional, teacher-centered approaches may not be compatible with technology-rich environments, which tend to support more student-centered, inquiry-based learning [8,17,21]. This transition can be difficult for lecturers who are accustomed to more traditional methods and who may feel apprehensive about adopting new technologies.

To address these challenges, ongoing professional development and training programs are essential. Research has revealed that professional development programs focused on TPACK can significantly improve lecturers' confidence and competence in using technology [16]. Such training programs equip lecturers with the skills and knowledge they need to effectively use technology in a way that enhances learning outcomes. Moreover, professional development should be designed to be practical, offering hands-on experiences using digital tools and fostering collaboration among educators to share best practices [5]. These programs should also encourage lecturers to reflect on how their use of technology impacts student learning, enabling them to continually refine their teaching strategies and adapt to the evolving technological landscape [15].

Given the complexity of technology integration and the diverse contexts in which it is implemented, a mixed-method approach is necessary to gain a comprehensive understanding of the issue. Quantitative data can provide insights into the measurable outcomes of technology integration, such as student performance and engagement. However, qualitative data are equally important because they capture the experiences and perceptions of educators and students, which are often not reflected in quantitative measures [23]. Mixed-method studies allow for a more holistic examination of how technology is integrated into educational settings. By combining quantitative and qualitative data, researchers can identify not only whether technology integration is effective but also how and why it works in specific contexts. This approach is particularly valuable in higher education, where the diversity of teaching practices and technological tools makes it difficult to generalize findings from one context to another [23,24].

This study focuses explicitly on in-service university lecturers as the primary target participants. Specifically, the training program was designed for faculty members at Amasya University's Faculty of Education who are actively engaged in teaching but seek to enhance their technology integration skills within the TPACK framework. By targeting in-service lecturers, this study addresses the unique challenges faced by experienced educators in updating their pedagogical practices, distinct from pre-service teacher training programs that prepare novices for initial classroom entry. While this study adopts certain pedagogical strategies (e.g., flipped classrooms, collaborative activities) commonly used in pre-service training, its design and objectives are firmly rooted in the needs of in-service professionals. In-service training differs fundamentally from pre-service programs in its emphasis on enhancing existing competencies rather than building basic skills. This program prioritized hands-on, discipline-specific applications of technology, recognizing that in-service lecturers already possess content expertise but require support in aligning technology with their pedagogical goals. The mixed-methods approach, including needs assessments and iterative feedback, ensured that the training addressed gaps identified by the participants themselves, a critical feature of effective in-service professional development [19].

Existing literature underscores the importance of continuous professional development for in-service educators, particularly in rapidly changing technological landscapes [10,13]. Unlike pre-service training, which often emphasizes theoretical frameworks, in-service programs must balance practical immediacy with reflective practice [17]. This study's TPACK-based intervention aligns with this principle by integrating real-world tools (e.g., Edmodo, Quizizz) into lesson planning while encouraging lecturers to reflect on their teaching practices. By narrowing the scope to in-service faculty, this research contributes to understudied areas of higher education professional development, bridging the gap between TPACK theory and the contextual realities of experienced educators [25]. The purpose of this study is to prepare and implement an in-service training program to increase lecturers' technology awareness within the scope of the TPACK model and to evaluate the effectiveness of such an in-service training program. In line with this objective, answers to the following questions were sought.

1. What are the needs of lecturers for in-service training programs to increase technology awareness within the scope of the TPACK model?
2. Is there a difference between the pre-test and post-program mean scores of lecturers' technology integration awareness before and after the in-service training program?
3. What are the lecturers' opinions on the effectiveness of an in-service training program implemented within the scope of TPACK?

2. Method

2.1. Research design

This exploratory mixed-methods case study employed a small sample that integrated both qualitative and quantitative approaches to gain a comprehensive understanding of the impact of an in-service training program aimed at increasing technology integration awareness among lecturers within the TPACK model [23]. The nested design was chosen because it allows for a more nuanced analysis by collecting and integrating both types of data, providing richer insights than would be possible through either method alone. Qualitative data were initially collected to assess the participants' needs and expectations regarding technology integration. This was followed by quantitative data collection through pre- and post-tests to measure changes in participants' awareness of technology integration before and after the intervention. Finally, qualitative data were collected again through semi-structured interviews to evaluate the participants' perspectives on the effectiveness of the training program. This sequential combination of qualitative and quantitative data helped triangulate the findings, enhancing the validity of the study conclusions.

2.2. Participants

This study employed convenience sampling to recruit participants. Four lecturers from the Faculty of Education at Amasya University were selected as participants. Amasya University, located in Türkiye, serves a diverse student population with varying levels of access to technology. The Faculty of Education, where the study was conducted, has been increasingly focusing on integrating technology into teaching practices, particularly in response to the COVID-19 pandemic, which accelerated the adoption of remote learning tools.

The recruitment process began with the identification of potential participants from the Faculty of Education at Amasya University. A total of 20 lecturers were initially contacted via email, with follow-up reminders sent after one week to encourage participation. The email included a detailed description of the study's objectives, the structure of the in-service training program, and the potential benefits of participating in the program. Lecturers were informed that the training would focus on enhancing their technology integration skills within the TPACK framework and that their participation would contribute to the broader understanding of technology integration in higher education. Despite the initial outreach, only four lecturers agreed to participate. The primary reasons for the low response rate included time constraints, heavy teaching workloads, and limited prior experience with technology integration. Some lecturers expressed concerns about their ability to commit to the training program due to other professional and personal responsibilities. However, the four participants who agreed to join the study were highly motivated and expressed a strong interest in improving their technology integration skills. To ensure that the participants were representative of the broader faculty, efforts were made to include lecturers from different departments and with varying levels of teaching experience. Although the final sample size was small, the participants represented a diverse range of academic backgrounds, teaching experiences, and technological proficiency levels, which provided valuable insights into the challenges and opportunities of technology integration in higher education.

2.3. Training program overview

The in-service training program was designed to enhance lecturers' awareness and skills in technology integration within the TPACK framework. The program was structured around a series of hands-on, interactive activities that introduced participants to various technological platforms and tools, such as Edmodo, Quizizz, LearningApps, and Coggle. The training was divided into three main phases: pre-service training activities, in-service training activities, and post-service training activities. Each phase was carefully designed to address the specific needs identified during the needs assessment phase and to provide participants with practical, hands-on experiences in technology integration.

The in-service training program was designed with a clear focus on enhancing lecturers' awareness and skills in technology integration within the TPACK framework. The design was guided by several core principles and values, which were informed by the needs assessment and the theoretical underpinnings of the TPACK model. These principles include participant-centered learning, collaborative and interactive learning, integration of theory and practice, flexibility and adaptability, reflective practice, and alignment with the TPACK framework. The training program was tailored to address the specific needs and preferences of the participants, as identified during the needs assessment phase. This approach ensured that the content was relevant and directly applicable to the lecturers' teaching contexts. The training emphasized small group activities and interactive workshops. This approach not only fostered a supportive learning environment but also encouraged participants to share the best practices and learn from each other's experiences.

The training program was designed to balance theoretical foundations with practical applications. Participants were introduced to the TPACK framework and its relevance to their teaching practices, followed by hands-on activities that allowed them to experiment with various technological tools. Given the varying levels of technological proficiency among participants, the training program was designed to be flexible and adaptive. The use of multiple technological platforms (e.g., Quizizz, LearningApps, Prezi) allowed participants to explore tools that best suited their teaching styles and subject areas. A key component of the training was the emphasis on reflective practice. Participants were encouraged to reflect on their learning experiences and consider how they could integrate technology into their teaching in meaningful ways. The training program was explicitly aligned with the TPACK framework, which emphasizes the interplay between technological knowledge, pedagogical knowledge, and content knowledge. The use of TPACK-based lesson plans and interactive activities helped participants understand how to align technology with their specific teaching goals and subject matter.

The training program was built on several core values that guided its design and implementation including relevance, practicality, collaboration, reflection, and innovation. The training content was directly tied to the participants' teaching contexts, ensuring that the skills and knowledge gained were immediately applicable. The program prioritized hands-on, practical activities over theoretical lectures. Participants were given opportunities to experiment with various technological tools and platforms, allowing them to gain confidence in using these tools in their teaching. The training fostered a collaborative learning environment where participants could share ideas, challenges, and solutions.

2.4. Pre-in-service training activities for TPACK

To prepare participants for the in-service training, several activities were carried out in advance to ensure their familiarity with the technological platforms and content. First, a WhatsApp group was established with four participants to facilitate seamless communication and the dissemination of preliminary information. This group was used to coordinate training schedules, share materials, and address logistical issues that participants may encounter. Beyond WhatsApp, a classroom environment was set up on the Edmodo platform, which served as the primary learning management system (LMS) throughout the pre-training and training phases. In line with the flipped classroom model, the participants were required to engage with learning materials prior to their official in-service training sessions. A key component of this pre-training phase was a video on the observation method created by the researcher and uploaded to YouTube. This video provides an overview of the observation technique and its features, benefits, and limitations in the context of qualitative research. Along with the video, a set of questions was prepared to assess the participants' comprehension. The video and the questions were shared through Edmodo, allowing the participants to access and respond to the materials at their own pace.

In addition to the instructional video, supplementary materials were made available on the Edmodo platform to enhance the participants' understanding of technology integration in educational settings. These materials included a curated list of technology platforms that can be used in educational contexts, introductory videos demonstrating how these platforms function, and relevant internet news articles discussing the application of these platforms for distance education, a particularly important topic following the widespread adoption of remote learning tools during the COVID-19 pandemic. Participants were required to read and watch all of these resources prior to attending the in-service training to ensure adequate preparation. To assess the participants' baseline knowledge of technology integration, a pre-test was conducted. A link to this pre-test, prepared via Google Forms, was shared through Edmodo, allowing the participants to complete it in advance of the training. This pretest focused on evaluating participants' pre-existing knowledge of the TPACK framework as well as their familiarity with key technological tools that would be utilized in the training.

2.5. In-service training activities for TPACK

The in-service training was designed to provide a hands-on, interactive experience, guiding participants through the intricacies of technology integration using the TPACK framework. The central component of the training was a presentation titled "Technology Integration Training" created by the researcher using the Prezi platform. This presentation was structured to gradually introduce participants to both theoretical concepts and practical applications, with a focus on engaging and participatory learning. The training session began with an introduction based on a news article titled "Development of Academicians in Higher Education" that highlighted the growing need for technology integration in the academic field. Following this, the session moved into a detailed discussion of the distinction between *technology use* and *technology integration*. This differentiation was crucial because it underscored the importance of using technology not just as a tool but as an integral part of the learning process in alignment with the TPACK model.

Participants were then introduced to the TPACK framework through a TPACK Matching game, which was designed on the LearningApps platform. This game provided participants with an opportunity to test their understanding of the relationships between technological, pedagogical, and content knowledge. The use of interactive learning activities, such as this game, helped reinforce the theoretical concepts being taught in an engaging manner. Throughout the training, various platforms commonly used in remote education were introduced in response to the needs identified during the pre-training phase. These platforms included Google Classroom, Canvas, Moodle, and Microsoft Teams. The session also introduced applications designed to support interactive learning, such as Edmodo, Quizizz, LearningApps, and Coggle. Each of these platforms was explained in terms of its specific educational application, with demonstrations provided to ensure participants were comfortable using the tools. One of the highlights of the in-service training was the demonstration of a sample TPACK lesson plan, which was designed by the researcher using Gagné’s instructional model (Table 1).

Table 1. Examples of TPACK lesson plans.

Course title	Scientific Research and Publication Ethics		
Section	Department of Turkish Social Sciences Education, Social Studies Teaching Program		
Class	4th grade		
Duration	40 minutes		
Subject	Features, benefits, and limitations of observation techniques		
Gains	1. This observation explores the features, benefits, and limitations of the technique within the context of the flipped classroom model. 2. Designs a game on a technological platform to describe the features, benefits, and limitations of the observation technique.		
Strategy, methods, and techniques	Collaborative learning, question-answering, mind map, group work.		
Materials	Technological platforms (Edmodo, Quizizz, LearningApps, Coggle, Prezi)		
Measuring tools	Rubric (rating scale), question-answer platform (Quizizz)		
Stages	**Activity description**	**Online learning environment**	**Technological tools used**

Attracting attention	The lesson starts with a game.	A game activity related to the "observation method" is carried out on a technology platform on the web.	LearningApps platform
Information about the objectives of the course	At the end of this course, students will learn "the characteristics, benefits, and limitations of the observation technique, which is one of the qualitative research methods"; It is stated that it will be a course based on collaboration, including discussion, and in which the student will actively participate.	The objectives of the course are introduced through an infographic.	Prezi platform
Promoting recall of prerequisite information	Students will be reminded of the characteristics of the "qualitative research method".	A mind map is used.	Coggle mind mapping platform
Presentation of stimulating materials	The content of the video sent from the “Edmodo” platform is summarized. Incorrect answers to questions about the video are discussed.	The content of the YouTube video is displayed.	Edmodo platform
Guidance on what to learn	The characteristics, benefits, and limitations of the observation technique are emphasized.	A mind map of the features, benefits, and limitations of the observation technique is generated.	Coggle mind mapping platform
Unlocking performance	By dividing students into groups, they are able to reinforce their knowledge about the features, benefits, and limitations of the observation technique.	Students, divided into groups, are asked to design games about the features, benefits, and limitations of the observation technique and to introduce their designs and share them on the platform.	LearningApps platform
Feedback on performance	Feedback on students' progress is given.	Feedback is given to these games designed on the platform.	LearningApps platform
Evaluating performance	The students’ game designs are evaluated.	“Rubric” is used.	Edmodo platform
	The features, benefits, and limitations of the observation	Question-answer technique is	Quizizz platform

	technique are evaluated.	used.	
Keeping in memory and transferring (generalization)	A discussion environment is created for students about what they have learned at the end of the course.	At the end of the lesson, students are asked to share the points that come to mind on the platform.	Edmodo platform

Gagné’s model includes several key stages: gaining attention, informing learners of the objectives, recalling prior knowledge, presenting new material, providing learning guidance, eliciting performance, giving feedback, and enhancing retention and transfer. This lesson plan was used to demonstrate how technological platforms could be integrated into a cohesive learning experience that engaged students at multiple levels. For instance, the lesson began with a game-based activity on the LearningApps platform, followed by an infographic created on Prezi to inform participants about the course objectives. To further solidify the participants’ understanding, a mind-mapping activity was conducted using the Coggle platform. This activity allowed the participants to visually organize their knowledge of the observation method’s features, benefits, and limitations. The session ended when the participants were divided into small groups, where they were tasked with designing educational games related to the observation method. These games were created on the LearningApps platform and shared on Edmodo, allowing for peer review and collaborative learning. At each stage of the training, feedback was provided to the participants on their performances. This feedback was delivered verbally during the session and through the platforms used (e.g., Edmodo and LearningApps). Additionally, participants were encouraged to reflect on their learning through quizzes administered via the Quizizz platform, which further reinforced the material covered in the training.

2.6. Post-in-service training activities for TPACK

After the in-service training, participants were asked to respond to three open-ended questions designed to gather their views on the effectiveness of the program. These responses were analyzed using descriptive analysis to identify common themes and participant perceptions. To evaluate changes in participants' knowledge of technology integration, a post-test similar in format to the pre-test was administered via Google Forms and shared on Edmodo. Descriptive statistics were used to compare the participants’ scores before and after the training, and the difference in the arithmetic means of the pre-test and post-test scores was calculated. In addition, the open-ended responses from both the pretest and post-test were analyzed qualitatively to provide deeper insight into the participants’ learning experiences and any shifts in their understanding of technology integration.

2.7. Data collection tools

This study utilized three primary data collection tools to address its research objectives. These tools included semi-structured interviews for program design input, pre-test and post-test forms to assess technology integration knowledge, and a post-program semi-structured interview to evaluate program effectiveness. Each tool was carefully developed and validated to ensure its appropriateness for the study objective. For the first objective of this research, which aimed to design an in-service training program to enhance lecturers’ technology awareness within the TPACK model framework, participants' opinions were gathered using semi-structured interviews. This method was chosen because it allows for a predetermined set of questions while offering the flexibility to explore topics more deeply as they arise during the conversation [23]. The researcher prepared the initial interview questions, focusing on aspects such as achievement, content, training, and testing for the proposed program. To ensure the validity and comprehensiveness of the interview form, two field experts reviewed it, and their feedback was incorporated into the final version. The semi-structured interviews conducted during the needs assessment phase and post-training evaluation were guided by the following questions:

Needs assessment interview questions:

1. How do you currently integrate technology into your teaching practices?
2. What challenges do you face when integrating technology into your lessons?
3. What knowledge and skills would you like to focus on in the in-service training program?
4. What specific technological tools or platforms are you interested in learning more about?
5. How do you perceive the difference between technology use and technology integration in education?
6. What are your expectations from a training program focused on technology integration within the TPACK framework?

Post-training interview questions:

1. How would you describe your experience with the in-service training program?
2. What specific aspects of the training did you find most useful or impactful?
3. How has your understanding of technology integration changed after participating in the training?
4. What challenges, if any, did you encounter during the training?
5. How confident do you feel in applying the TPACK model in your teaching after the training?
6. What suggestions do you have for improving future training programs?

To address the second objective of the study, which involved determining participants' knowledge levels regarding technology integration before and after the in-service training program, pre-test and post-test forms were developed. These forms consisted of multiple-choice questions and one open-ended question designed to measure participants' awareness of technology integration. The questions in both the pre-test and post-test were identical to allow for a direct comparison of knowledge levels before and after the intervention. The researcher drafted the initial questions, which were then reviewed by two curriculum and instruction experts. Based on the feedback received, the forms were refined and finalized.

For the third objective, which sought to obtain participants' opinions on the effectiveness of the in-service training program, a post-program semi-structured interview was employed. This interview form was specifically designed to elicit participants' evaluation of the TPACK model after their completion of the training program. As with the other tools, the researcher prepared the initial questions, which were then reviewed by two curriculum and instruction experts. Their input was used to refine and finalize the interview form, ensuring its alignment with the research objectives and its effectiveness in gathering meaningful data on program effectiveness from the participants' perspectives. Through the development and use of these three data collection tools, this study aimed to gather comprehensive information on the design, implementation, and effectiveness of an in-service training program for enhancing technology awareness among lecturers within the TPACK model framework.

2.8. Data collection process

Participants' opinions were taken to determine the need for an in-service training program to be designed, which is the first sub-objective of the research. The interviews were conducted in each scholar's room and lasted approximately 15 minutes. The data obtained from the interviews were analyzed by descriptive analysis. Descriptive analysis is the interpretation and summation of data obtained in line with predetermined themes. Moreover, it is the presentation of data by considering the questions or dimensions used during observations or interviews [23]. Therefore, in this study, the responses to the interview questions were analyzed through descriptive analysis, and the obtained data were used for the design of an in-service training program.

Following the interviews conducted with four participants during the needs assessment phase, it was found that participants expressed their desire to focus on skills such as developing games within the scope of mobile learning, using online portals, using email communication, forming groups, learning technological tools used in distance education, being able to apply these tools systematically, gaining knowledge of technology integration, realizing its importance, and understanding the difference between technology use and integration. Therefore, the objectives of the in-service training were determined by explaining the concept of technology integration, explaining the TPACK model, providing examples of technological platforms used in distance education, and implementing some of these platforms within the scope of TPACK. As for the technology platforms, we decided to utilize applications commonly used in distance education such as Edmodo, Quizizz, LearningApps, and Coggle. Because the participants wanted to develop games within the scope of mobile learning, they were determined to utilize these platforms. In this respect, within the scope of Scientific Research and Publication Ethics, which is a common discipline for all participants, the topic of "Characteristics, benefits, and limitations of the observation method, which is one of the qualitative research methods" was determined as the content area for the TPACK lesson plan. First, Prezi was used to present the concepts of TPACK and technology integration and to show a few application examples and TPACK lesson plans used in the distance education process, as it was desired to organize activities in accordance with the techniques of learning by doing, showing, and making. Next, Coggle was used to present the characteristics, benefits, and limitations of the observation method within the scope of the lesson plan created in accordance with TPACK using technology platforms. Finally, lecturers were asked to carry out the TPACK application through an application and discipline area that they determined themselves. In the evaluation phase for the TPACK lesson plan, we decided to utilize a rubric as the evaluation method (Table 2).

Table 2. The rubric used as the evaluation method.

Qualifications	1	2	3	4
Technology platform use	Could not use the proposed technology platform.	Partially used the technology platform partially correctly.	Mostly used the technology platform correctly.	Used the technology platform completely correctly.
Game design	Could not create a game design.	Many parts were left out while designing the game.	Some parts were missing while designing the game.	The game was completely designed.
Adding features to game design	The subject content was written incorrectly while preparing the game design.	While preparing the game design, much of the plot content was misspelled.	While preparing the game design, some subject content was missed.	While preparing the game design, the author wrote the subject content completely correctly.
Introduction of game design and sharing of the process	Failed to promote and share game design.	Partially successful in introducing game design and sharing the process.	Some parts of game design and sharing process were missed.	The game design process was thoroughly introduced and shared.

2.9. Data analysis

Qualitative data were primarily obtained from interviews during the needs assessment phase and from open-ended questions after the training, and were analyzed using descriptive analysis. This method involves interpreting and summarizing data according to predetermined themes [23,24]. The analysis process included the transcription of interview recordings and compilation of written responses, identification of key themes based on research questions and interview structure, categorization of responses under relevant themes, summarization of findings within each theme, and selection of representative quotes to illustrate key points. Quantitative data analysis was primarily focused on the pre- and post-test results measuring participants' knowledge of technology integration. The analysis involved the calculation of descriptive statistics for both pre- and post-test scores and the comparison of arithmetic means between pre- and post-test results to determine the change in knowledge levels. To provide a comprehensive understanding of the training program's effectiveness, qualitative and quantitative data were integrated. This integration involved triangulation of interview responses, open-ended question responses, and test score improvements to validate findings, using qualitative data to explain and contextualize quantitative results, identifying any discrepancies between qualitative and quantitative findings, and exploring possible explanations. Member checking was also performed to review the accuracy of the research themes and interpretations with the participants.

2.10. Validity and reliability

The study’s construct validity was strengthened through the use of the TPACK framework, a well-established model for understanding technology integration in education [7,15]. The training and assessment tools were designed to align closely with this framework, ensuring that the constructs being measured were theoretically grounded. Content validity was addressed in the needs assessment phase. The semi-structured interviews conducted with participants helped ensure that the training program's content was relevant and appropriate for the target audience [23,24]. Additionally, the use of multiple technological platforms (e.g., Edmodo, Quizizz, LearningApps, Coggle) in the training program enhanced content validity by covering a broad spectrum of educational technology tools.

A weak pre-test–post-test design helped control for threats to internal validity by allowing for a direct comparison of participants' knowledge before and after the intervention [26]. This study employed a pre-test–post-test approach within a mixed-methods case-study framework to explore changes in lecturers' technology integration awareness. While the small sample size limits broad generalizability, the qualitative findings provide rich insights into educators' experiences, challenges, and growth. Qualitative case studies, even with a limited number of participants, offer valuable contextual knowledge that can inform future professional development programs in similar educational settings [27]. The identified themes provide a nuanced understanding of how targeted training can enhance lecturers' pedagogical and technological competencies. The use of a rubric to evaluate TPACK lesson plans and game designs provided a standardized assessment method, further enhancing internal validity. Although the small sample size (n = 4) limits generalizability, the detailed description of the training program and its implementation allows for potential replication in similar contexts, supporting a degree of external validity [26,28]. The mixed-methods approach allowed for methodological triangulation by combining qualitative interview data, quantitative test scores, and rubric-based assessments. This multi-faceted data collection and analysis strategy also enhances the overall validity and reliability of the findings [23,24]. Lastly, the participants reviewed the accuracy of the research findings and interpretations and further enhanced the credibility and validity of the qualitative findings [28].

3. Results

The analysis of the semi-structured interviews, pre-test and post-test data, and qualitative feedback revealed several key themes regarding lecturers' needs, experiences, and perceptions of technology integration in education within the TPACK model. The results are presented in the following sections: (1) participant characteristics, (2) pre-test and post-test results, and (3) qualitative findings.

3.1. Participant characteristics

A total of four university lecturers from Amasya University's Faculty of Education participated in the study. Table 3 presents a summary of their demographic characteristics, including age, years of experience, academic rank, and familiarity with technology integration.

Table 3. Participant characteristics.

Characteristics	*n*
Gender	
Male	3
Female	1
Age group	
26–35 years	1
36–45 years	2
46–55 years	1
Department	
Turkish Language and Social Sciences Education	2
Primary Education	2
Years of experience	
6–10 years	2
11–15 years	2

There were three male lecturers (75%) and one female lecturer (25%). The age range of lecturers was 26–35 (*n* = 1, 25%) 36–45 (*n* = 2, 50%), and 46–55 years (*n* = 2, 50%). Professional experience was evenly distributed between 6 and 10 years (*n* = 2, 50%) and 11 and 15 years (*n* = 2, 50%). Educational attainment was balanced between doctoral degrees (*n* = 2, 50%) and master's degrees (*n* = 2, 50%). In terms of academic rank, there was an equal distribution of Associate Professors (*n* = 2, 50%) and Research Assistants (*n* = 2, 50%). The majority of participants (*n* = 3, 75%) were affiliated with the Department of Turkish Language and Social Sciences Education, while one participant (25%) was from the Department of Primary Education.

3.2. Pre-test and post-test results

The pre-test and post-test assessments were used to evaluate changes in participants' knowledge of technology integration. Table 4 presents the descriptive statistics for the scores before and after the training program.

Table 4. Pre-test and post-test results.

Measurement	*M*	*SD*	Mean difference
Pre-test	13.75	2.15	3.50
Post-test	17.25	1.76	

As seen in Table 4, the mean post-test scores indicate a significant improvement in participants' technology integration awareness following the training program.

3.3. Qualitative findings: emerging themes

The qualitative data from the interviews and open-ended questions revealed several themes regarding participants' perceptions of technology integration and their experiences with the training program. Table 5 reports these themes and their descriptions.

Table 5. Emerging themes from the research process.

Theme	Description
Current knowledge and skills	Participants had varying levels of knowledge about educational technology and technology integration; some confusion between technology use and integration was noted.
Training needs	Participants expressed interest in learning about remote education tools, game development, online portals, and the distinction between technology use and integration.
Content preferences	Participants preferred hands-on activities, workshops, role-playing, and learning by doing.
Evaluation methods	Suggestions included product-based assessment, practical application, and peer assessment.
Training effectiveness	Pre-test and post-test results showed improvement in knowledge; participants reported increased awareness and understanding of technology integration.
TPACK model reception	Participants viewed the TPACK model positively, recognizing its importance in modern education.
Training environment	Preferences for small groups, face-to-face interaction, and a comfortable, cooperative learning environment were expressed.
Challenges and areas for improvement	Challenges and areas for improvement were identified.

As shown in Table 5, the emerging themes from the research process were current knowledge and skills, training needs, content preferences, evaluation methods, training effectiveness, the reception of the TPACK model, and the training environment. More detailed information about each theme is presented below.

3.3.1. Current knowledge and skills

At the outset of the study, the participants demonstrated varying levels of understanding of educational technology and integration. It became evident that there was some confusion between the concepts of technology use and integration among the participants. As Lecturer 4 noted, "When it comes to educational technology, I actually understand the technical infrastructure necessary for the implementation of educational processes." This statement reflects a common initial focus on technical aspects rather than pedagogical integration. Lecturer 1 offered a slightly different perspective: "I think of technology as an effective use of technology in educational processes, more precisely in learning and teaching processes. Technological tools include computers, virtual reality, and other artificial environments; I don't use software much." This response indicates a broader understanding of educational technology but still lacks a clear distinction between use and integration. These varied responses highlight the need for a standardized understanding of technology integration in education among lecturers. The disparity in knowledge and skills among participants sets the stage for the training program’s objectives.

3.3.2. Training needs and content preferences

The interviews revealed that the participants had diverse training needs and content preferences. These needs span basic technology skills to more advanced technology integration concepts. For example, Lecturer 2 expressed interest in "Developing small-scale simple games on Android phones." The content preferences were extended to better understand the TPACK model and its practical applications. Lecturer 4 emphasized the importance of a comprehensive approach: "I think why Technology Integration is important should be taught in very simple steps, attention should be drawn to this issue. Programs should be taught, and applications should be taught." Lecturer 1 suggested a more structured approach to content: "We can talk about the scope of educational technologies and then discuss how this integration should be used and how to adapt it to the program." This recommendation helped organize the training content in a logical and progressive manner. These diverse needs and preferences informed the development of a comprehensive training program that addressed both theoretical understanding and practical application of technology integration in education.

3.3.3. Learning activities and training environment

Participants showed a strong preference for hands-on experiential learning activities. This preference was consistently expressed by all participants, regardless of their initial level of technological proficiency. Lecturer 2 articulated this sentiment clearly: "In short, I can say learning by doing and experiencing if we can try some things with our own means at such an introductory level as well as just explaining them." This comment underscores the importance of active learning in technology integration training. Lecturer 1 suggested the following interactive learning methods: "Drama can be used; there can be role-playing, role-playing activities with drama, or one-to-one micro-teaching with these contents. I care more about micro-level, applied activities." This recommendation for diverse and engaging learning activities helped shape the pedagogical approach of the training program. Lecturer 3 proposed the following workshop format: "Workshops during in-service training can make learning more enjoyable for people." This suggestion aligns with the principles of adult learning and emphasizes the importance of enjoyment and engagement in professional development activities.

The participants favored small group settings for more effective learning. Lecturer 4 suggested, "I think these can be taught in very small groups with a small number of people in small groups of 3 or 5 people with one Scholar." This preference for intimate learning environments informed the structure of the training sessions. Lecturer 3 emphasized the importance of a comfortable learning environment: "People should be comfortable. I mean, they should be relaxed, not in tension, but relaxed. I think it would be healthier if it happened in a face-to-face environment." This insight highlighted the need for a supportive, low-stress learning atmosphere to maximize engagement and learning outcomes. These preferences for active learning, small group interactions, and a comfortable environment were integral in designing an effective and engaging training program.

3.3.4. Evaluation methods

Participants, particularly those new to technology-enhanced instruction, proposed various assessment strategies, with a strong emphasis on practical application and product-based evaluation. For example, Lecturer 3, who had limited prior experience with educational technology noted: "I think that the products that a person produces after a certain process will show you whether he/she has really gained something in this in-service training. For me, creating a game using LearningApps was challenging at first, but it helped me understand how technology can be integrated into my teaching." This feedback highlights the importance of hands-on, practical evaluation methods for beginners, as they provide tangible evidence of learning and skill development. Lecturer 4 suggested a more personalized approach to evaluation: "Let us be advised to use this technology for what we want, what we like, and what we want." This recommendation emphasizes the importance of relevance and personal interest in the assessment process. Lecturer 1 proposed a technology-based evaluation: "An evaluation can be made based on a technological educational technology." This suggestion aligns with the content of the training, ensuring that the assessment method matches the skills being taught. Lecturer 2 focused on practical demonstration of skills: "In the evaluation phase, I think you should show where and what it does on the menus." This comment underscores the importance of being able to navigate and utilize the technologies introduced in the training. These diverse perspectives on evaluation informed the development of a multi-faceted assessment approach that included product creation and practical skill demonstration.

3.3.5. Training effectiveness and reception of the TPACK model

The pre-test and post-test results indicated a significant improvement in the participants' knowledge of technology integration, with the mean score increasing from 13.75 to 17.25. Qualitative feedback supported this quantitative improvement. Lecturer 4 commented on the effectiveness of the workshop: "The workshop was very useful. Technology integration is a process that can be learned only when we experience it. In the workshop, we learned many programs both theoretically and practically." Participants viewed the TPACK model, recognizing its relevance in contemporary education. Lecturer 1 emphasized the following points: "When technology is being used so intensively, I think it would be unwise to run away from technology and try not to integrate it into education processes. It is definitely very important." Lecturer 2 reflected on their expanded understanding post-training: "After the workshop, I realized that technology integration in education is an opportunity that can be utilized in an extremely wide range of areas. While integrating technology, it is possible to use ordinary infrastructures that are used in daily life, as well as the opportunity to use redesigned versions of similar structures according to the educational setting." This comment demonstrates a significant shift in perspective and a broader understanding of the possibilities for technology integration.

3.3.6. Benefits of technology platforms

The wide range of technological options presented during the training was well received. Participants appreciated the potential to address diverse learning styles. Lecturer 2 noted, "First of all, the fact that this range is so wide and I have seen it in the context of this study has been very useful. Besides, its contribution to education is that there are various learning methods for students."

Lecturer 1 specifically mentioned the utility of Web 2.0 tools as follows: "I especially think that the use of Web 2.0 tools (patlet, kahot, etc.) in the distance education process will make the course more effective." The positive reception of various technology platforms suggests that the training successfully introduced participants to a range of useful tools, expanding their technological repertoire for educational purposes.

3.3.7. Challenges and areas for improvement

Although the overall reception of the training was positive, some challenges and areas for improvement were identified. These insights are valuable for refining future training programs. One challenge was the variation in baseline knowledge among the participants. Lecturer 2 initially stated, "I think my knowledge of technology integration in education is limited in general." The observed disparity in initial knowledge levels suggests the need for flexible training programs that can accommodate different starting points. Another area of consideration was the balance between theoretical knowledge and practical application. While the participants appreciated the hands-on aspects, they also expressed a desire for deeper theoretical understanding. Lecturer 4 suggested, "After the theoretical knowledge is explained, of course we need to be shown, we need to learn by doing." This comment highlights the importance of effectively blending theory and practice. The time constraint was also mentioned as a potential challenge. Lecturer 3 implied this when saying, "I think that the products that a person produces after a certain process will show you whether he/she has really gained something." This suggests that longer-term follow-up might be beneficial for fully assessing the impact of the training.

Overall, the program’s success is evident in the quantitative improvement in test scores and the qualitative feedback from the participants. Lecturers reported increased awareness of technology integration possibilities, a better understanding of the TPACK model, and greater confidence in using various technological platforms for educational purposes. The preferences expressed by participants regarding hands-on learning, small group interactions, and a comfortable learning environment proved to be effective strategies for facilitating learning. The diverse evaluation methods suggested by the participants and their incorporation into the program allowed for a comprehensive assessment of learning outcomes. While challenges were identified, particularly in addressing varying baseline knowledge levels and balancing theory with practice, these insights provide valuable directions for future training program iterations. Consequently, this study demonstrates the effectiveness of a well-designed, participant-informed in-service training program for enhancing lecturers’ technology integration skills within the TPACK framework.

4. Discussion

The TPACK framework served as the foundation for the training program, guiding the design and implementation of activities that emphasized the interplay between technological knowledge, pedagogical knowledge, and content knowledge. The results of this study align with previous research that highlights the effectiveness of TPACK-based training in improving educators' ability to integrate technology meaningfully into their teaching [17]. The participants' increased awareness of technology integration and their improved ability to differentiate between mere technology use and meaningful integration underscore the value of the TPACK framework in guiding professional development. The training program was designed to address the specific needs of the participants, as identified during the needs assessment phase. This approach ensured that the content was relevant and directly applicable to their teaching contexts. The hands-on, collaborative nature of the training allowed participants to engage with various technological tools (e.g., Edmodo, Quizizz, LearningApps, Coggle) and reflect on how these tools could be integrated into their teaching practices. This experiential learning approach is consistent with the principles of adult learning and has been shown to be effective in fostering technology integration skills [9].

The findings of this study suggest that the program was successful in increasing the participants' knowledge and confidence in technology integration, as evidenced by the improvement in the pre- and post-test scores and qualitative feedback from the participants. This outcome is consistent with the broader literature on TPACK-based interventions. However, it has extended the application of TPACK to university lecturers, building upon work such as Marlinda et al. [16]. This expansion to higher education contexts contributes to a growing body of evidence supporting the effectiveness of TPACK-based approaches across various educational levels and settings [16,17,21]. The positive results observed in this study reinforce the potential of structured framework-based professional development to enhance educators' capacity for meaningful technology integration.

The results indicate that the in-service training program effectively addressed gaps in lecturers' understanding of technology integration and provided them with practical skills to apply in their teaching. This aligns with previous research highlighting the importance of professional development programs focused on TPACK to improve teachers' confidence and competence in using technology [22,25]. The improvement in the participants' ability to differentiate between mere technology use and meaningful technology integration is particularly noteworthy because it addresses a common misconception among educators. The success of the program can be attributed to several factors. First, the needs assessment conducted before the training allowed for tailoring the content to address both general technology integration concepts and specific applications within the disciplines under study. This approach is supported by research suggesting that effective professional development should be relevant to teachers' specific contexts and needs [19,29]. Personalized professional development increases teacher engagement and the likelihood of implementing new practices [30]. Second, the hands-on, collaborative approach of the training program was well received by the participants. This aligns with adult learning principles, which emphasize the importance of practical, hands-on experience with digital tools in fostering collaboration among educators. The use of various technological platforms (e.g., Edmodo, LearningApps, Coggle, Quizizz) provided participants with a range of tools to explore and integrate into their teaching practices, addressing the need for diverse technological experiences highlighted by Ning et al. [16]. This approach is supported by research indicating that exposure to multiple technologies enhances educators' ability to select appropriate tools for specific educational contexts [16–18,21].

The positive reception of the TPACK model by participants supports its relevance and applicability in contemporary higher education settings. Participants' increased understanding of the interplay between technology, pedagogy, and content knowledge aligned with the model's core principles [7,31]. This understanding is crucial for effective technology integration because it emphasizes the importance of considering not only the technology itself but also how it interacts with pedagogical approaches and content delivery. Recent studies have reinforced the value of the TPACK framework in guiding technology integration efforts in higher education [32,33]. The participants' improved ability to conceptualize technology integration within their disciplines is particularly encouraging. This suggests that the training program successfully addressed the challenge of helping faculty members understand the relevance of technology integration to their teaching contexts, which is a key factor in promoting the adoption and sustained use of educational technologies [10,34]. This finding is consistent with research indicating that discipline-specific technology integration training is more effective than generic approaches [12,35].

Despite the overall success of the program, some challenges and areas for improvement were identified. One of the key challenges in technology integration is the varying levels of technological proficiency among educators. The TPACK framework, with its emphasis on the intersection of technology, pedagogy, and content, provides a structured approach to addressing this challenge. By focusing on the integration of these three domains, the training program helped participants understand how technology can be used to enhance pedagogical practices and support content delivery. This is particularly important in higher education, where lecturers often have strong content expertise but may lack the pedagogical and technological knowledge necessary for effective technology integration [16,36]. The participants' positive reception of the TPACK model and their increased confidence in using various technological platforms suggest that the framework is a valuable tool for guiding technology integration efforts in higher education. The findings also highlight the importance of providing lecturers with opportunities to explore and experiment with different technologies in a supportive, collaborative environment. This approach not only enhances their technological skills but also encourages them to reflect on how technology can be used to achieve specific learning outcomes.

Recent studies have proposed adaptive learning approaches to address this issue in technology-focused professional development [36]. The balance between theoretical knowledge and practical application emerged as another area for consideration. While the participants appreciated the hands-on aspects of the training, they also expressed a desire for deeper theoretical understanding. This tension reflects the ongoing debate in educational technology research about the appropriate balance between theory and practice in professional development programs [15,37]. Some researchers have argued for a more integrated approach that seamlessly blends theoretical foundations with practical applications [38,39].

The time constraint mentioned by some participants suggests that longer-term follow-up might be beneficial for fully assessing the impact of the training. This finding aligns with research indicating that sustained, ongoing professional development is more effective than one-off training sessions in promoting lasting change in teaching practices [19]. Recent studies have explored the potential of online communities of practice and micro-learning approaches to provide ongoing support and reinforce learning over time [40,41]. The feedback from participants, particularly those with limited experience in technology-enhanced instruction, highlighted the importance of providing clear, step-by-step guidance during the evaluation process. Beginners often struggled with navigating new platforms, such as LearningApps and Coggle, and expressed a need for more structured support. Future training programs could address this by incorporating additional scaffolding, such as video tutorials or guided practice sessions, to help participants build confidence in using these tools.

5. Limitations

This study has several limitations that should be considered when interpreting the results. First, this study included only four university lecturers (n = 4). The small sample size limits the generalizability of the findings and prevents more robust statistical analyses. Future research could address the limitation of the small sample size by conducting a larger-scale study involving multiple universities or faculties. A longitudinal study could also provide deeper insights into the long-term impact of TPACK-based training programs on lecturers' technology integration practices. Additionally, cross-cultural comparisons could help determine the universality of the findings across different educational contexts. Moreover, all participants had 6–15 years of teaching experience, which may not represent the broader spectrum of university lecturers. This homogeneity in participant demographics further limited the generalizability of the findings. Second, the absence of a control group limits our ability to attribute changes directly to the training program rather than to other factors. Furthermore, the study relied heavily on self-reported data, which may have been subject to social desirability bias or limited self-awareness of participants' own skills and knowledge. Third, although used for solely descriptive purposes, the self-developed questionnaire used to assess TPACK has not been validated; this potentially affects the reliability and validity of the results. Future studies should consider using or developing validated instruments specific to higher education contexts.

Fourth, while the study introduced several platforms (e.g., Edmodo, LearningApps, Coggle, Quizizz), it did not cover the full range of available educational technologies. This may limit the breadth of university lecturers’ exposure to technology integration options. In addition, the focus on currently popular technologies may not account for rapid advances in the field. Fifth, this study was conducted at a single faculty of education, which may not represent the diversity of higher education institutions or faculty experiences across different contexts. Moreover, this study was conducted in Amasya. Thus, the study results may not be applicable to higher education contexts in other cultural or geographical settings. Cross-cultural comparisons could provide valuable insights into the universality of the findings. Sixth, this study primarily focused on the TPACK framework, which may not capture all aspects of technology integration in higher education. Future research could consider incorporating multiple theoretical perspectives to provide a more comprehensive understanding of technology integration processes.

6. Practical implications

This study offers several practical implications for researchers, teacher educators, and policymakers interested in improving technology integration in higher education. The findings suggest that in-service training programs, particularly those rooted in the TPACK model, can effectively enhance lecturers’ awareness of technology integration and provide them with practical skills to implement technology in teaching. Thus, institutions can use this model as a framework for designing their own faculty development programs. By incorporating such training into professional development programs, higher education institutions can better equip lecturers to integrate educational technologies in meaningful ways, which, in turn, can enrich students’ learning experiences. Additionally, this study highlights the importance of addressing the distinct needs of lecturers when designing training programs. Tailoring content to address both general technology integration concepts and specific applications within the discipline of the lecturers was key to the success of the training. As such, future training programs should include hands-on activities, personalized content, and opportunities for collaborative learning to maximize engagement and skill acquisition.

The success of the program's hands-on, collaborative approach also suggests that future training should prioritize active learning and peer collaboration rather than passive instruction. Training should also include examples and applications specific to different disciplines to help faculty members understand the relevance of each teaching context. Moreover, policymakers in higher education could support the ongoing professional development of faculty by offering regular, sustained technology integration training sessions. These efforts could help bridge the gap between the growing availability of technological tools in education and educators' practical ability to use these tools effectively. A focus on continuous learning in the evolving technological landscape will also ensure that educators are up to date with the latest innovations.

7. Conclusions

This study aimed to develop, implement, and evaluate an in-service training program to enhance lecturers' awareness and skills in technology integration within the TPACK framework. The results indicate that the program successfully increased the participants' knowledge and confidence in technology integration. The pre- and post-test results, along with qualitative feedback from the participants, suggest that the training program effectively addressed gaps in lecturers' understanding of technology integration and provided them with practical skills to apply in their teaching. Participants showed improved differentiation between mere technology use and meaningful technology integration and expressed increased confidence in their ability to incorporate various technology platforms into their teaching practices. The study highlights the importance of providing targeted, hands-on training for faculty members in educational technology integration. The study also underscores the value of the TPACK model as a framework for conceptualizing and teaching the complex interplay between technology, pedagogy, and content knowledge in education. In conclusion, as technology continues to play an increasingly central role in education, faculty members, particularly those involved in teacher education, must be well-equipped to model effective technology integration. This study provides valuable insights into how higher education institutions can support faculty in developing these essential skills, ultimately contributing to the preparation of future teachers who are ready to leverage technology effectively in their classrooms.

Use of Generative-AI tools declaration

The authors declare they have not used Artificial Intelligence (AI) tools in creating this article.

Conflict of interests

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethics declaration

The author declared that no ethics approval is required for the study.

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