Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

The development of skills and awareness in integrating content, teaching methods, and technology in the learning management for teachers in the education sandbox, Thailand

Suntonrapot Damrongpanit [1, *], Suthida Chamrat [2], Monnapat Manokarn [1]

[1]*Department of Educational Foundation and Development, Faculty of Education, Chiang Mai University, Chiang Mai, Thailand*
[2]*Department of Curriculum, Teaching and Learning, Faculty of Education, Chiang Mai University, Chiang Mai, Thailand*

ARTICLE INFO

Article history:
Received 19 July 2023
Received in revised form
9 November 2023
Accepted 9 November 2023

Keywords:
TPACK
Technology integration
Teaching capability
Teacher development

ABSTRACT

This research aims to develop science teachers teaching in innovative educational institutions in Thailand, with a total of 68 participants, to have integrated skills in content and technology management and to increase their awareness of technology integration in the classroom. The development approach used the concept of Technological Pedagogical Content Knowledge (TPACK) combined with online blended learning, focusing on knowledge development, practical training, and application over a period of approximately three months. The data were analyzed using descriptive statistics, cross-tabulation analysis, and content analysis. The main findings of the research are as follows: 1) The trained teachers showed improvement in various aspects ranging from 17.201% to 22.727%, with the highest development observed in TPK, followed by PCK and PK. The area with the least improvement was TK. In addition, it was found that the integration of technology in instructional design by teachers tended to increase by two levels. The most commonly used technology was for learning management, followed by communication, knowledge testing, instructional media creation, and the use of educational games, and 2) the majority of teachers demonstrated an increasing awareness of integrating content management with technology in their teaching practices. They actively sought out new technological networks to support their instructional design activities. They planned their work to improve instruction through more effective use of technology. They sought additional ways to increase their knowledge and expertise in using technology in the classroom, and they expressed significant concerns about their current use of technology and its declining impact.

1. Introduction

The increasing reliance on digital technology in global society has led countries worldwide to strive for the development of youth who are on par with and thriving in the new digital era (Bates, 2015), ensuring balance and happiness. Technology plays a role in making life convenient, reducing the burdens of daily living, and keeping up with new societal and global changes. Therefore, educational organizations are considered crucial forces in nurturing and enhancing technological and innovative learning competencies in youth, enabling them to embrace the culture of the new era (Boyd, 2014; Shirky, 2010). Consequently, the traditional approach to providing learning experiences for students, which separates technology applications, lacks familiarity with technology and emphasizes partial skills for numerous professions unrelated to technology, is no longer suitable in a society where technology is rapidly disappearing. Therefore, it should undergo a new revision. Thailand is one of the global communities that recognizes the importance of preparing youth through educational management reform, as the traditional methods cannot adequately equip individuals to face change and thrive in the new world (UN, 2015). Therefore, the establishment of an educational management space called education sandbox has been initiated to focus on developing the education system and reducing the constraints of long-standing educational

* Corresponding Author.
Email Address: suntonrapot.d@cmu.ac.th (S. Damrongpanit)
https://doi.org/10.21833/ijaas.2023.11.025
Corresponding author's ORCID profile:
https://orcid.org/0000-0001-8143-2873

practices, as declared by ESMO (2019). This government project aims to bring education into a new era, promoting the use of technology and teaching innovation to enhance learning effectiveness and prepare students for a society of change and new opportunities in the future. Thus, the education sandbox project is a significant mechanism and a hope for a prototype practice to expand and transform the quality of education in the country (Suwanmanee et al., 2023). However, despite its intriguing principles, the transition to new teaching approaches still faces challenges and uncertainties.

The main challenge hindering the development of the education system in education sandbox is the deployment of teachers with diverse educational qualifications to teach content based on process-oriented and technology-dependent approaches. Some teachers lack proficiency in teaching content through education sandbox and are unfamiliar with or inexperienced in using technology for instructional purposes. They lack the skills to use instructional technology, have limited time to learn about technology and its utilization, and lack knowledge in effectively assessing and evaluating students using technology that aligns with the desired characteristics of education sandbox. Furthermore, the learning approaches still lag behind and are separated from the integration of technology (Sulistiani et al., 2024; Kokandy, 2021; Koh et al., 2015; Mangkhang et al., 2021).

This research aims to utilize the concept of developing teachers to reduce limitations and enhance confidence and awareness in utilizing the benefits of technology among teachers through the Technological Pedagogical and Content Knowledge (TPACK) framework, combined with Online Blended Learning (OBL) (Angeli and Valanides, 2009; Baris, 2015). The direct focus is to elevate technology-integrated learning management to create a sustainable professional culture for teachers, serving as a significant process-oriented guiding model for expanding the educational management outcomes of schools in the innovative education domain.

2. Literature review

2.1. Education sandbox

The education sandbox or Education Innovation Zone is a designated area strategically focused on driving educational development to significantly enhance Thailand's global competitiveness in the 21st century. This concept is rooted in the idea of developing spaces that promote growth in various aspects, including the economy, society, culture, and technologies that impact the lives of everyone in the community (Mangkhang et al., 2021; Palomino et al., 2020; Spours et al., 2020). One key characteristic of this initiative is fostering collaboration among schools, businesses, and organizations within the community. It aims to apply interdisciplinary approaches to encourage students to connect their knowledge to real-world problem-solving, promote hands-on learning, and, importantly, develop critical problem-solving skills and reasoning abilities (Mangkhang et al., 2021). It was announced and enforced starting from under the Royal Thai Government Gazette. Its key objectives are: 1) to innovate and develop educational and learning innovations to enhance student's educational outcomes, 2) to reduce educational disparities, 3) to decentralize power and grant autonomy to educational agencies and leading educational institutions within the innovation zone to enhance flexibility in educational management and quality, and 4) to create and develop mechanisms for collaborative educational management among the government sector, local administrative organizations, private sector, and civil society in the zone. Initially, there were six leading provinces, with Chiang Mai being one of the six in the innovation zone (ESMO, 2019).

For the province of Chiang Mai, it is an area that has experienced rapid growth in various aspects. It is renowned for its rich traditions, culture, and natural environment, which continuously attract tourists from around the world. However, in terms of education, there are significant challenges that impede progress, like overall educational development. These challenges include educational opportunities that are not equally accessible, low learning outcomes, a lack of teaching techniques that promote critical thinking, and a lack of contemporary knowledge integration with evolving careers in the current era. In terms of teachers and educational personnel, which number around 28,969 individuals, it is insufficient for effective teaching and learning management. The teacher-to-student ratio does not meet the standards, with many teachers having to teach without proper qualifications. The teacher development system is also ineffective, and there is a need to transfer teachers from remote areas to fulfill duties in urban communities. Moreover, there is a lack of motivation to attract knowledgeable and capable individuals to join the education system.

Based on the challenges, the education sandbox task force has conducted a selection and announced a list of 61 educational institutions in Chiang Mai province, divided into five development groups. These groups are as follows: 1) Educational management for academic excellence at the international level: This group focuses on utilizing new concepts, methods, processes, instructional media, or management approaches to elevate academic performance. It includes innovative management and instructional methods to enhance learning outcomes, 2) Vocational-oriented education for students in the context of Chiang Mai province: This group aims to develop students by incorporating community resources, local context, and student needs into innovative management and instructional methods. It focuses on preparing students for successful careers, 3) Problem-solving skills in critical thinking, analysis, reading, and writing: This group emphasizes new management and instructional methods that address reading and writing difficulties. It aims to enhance problem-solving skills through innovative approaches to management, teaching, and learning, 4) Inclusive education for children with special needs: This group employs new management and instructional methods to support educational opportunities and reduce educational disparities for students with special needs. It aims to create equal learning opportunities and reduce educational inequalities, and 5) Improving quality of life and enhancing well-being: This group focuses on new management and instructional methods to address life quality issues and enhance overall well-being. It aims to improve the living conditions and quality of life for students in various diverse areas. These groups are designed to drive educational development and address the specific challenges in Chiang Mai province (ESMO, 2019).

2.2. Awareness of learning integrated with technology

In addition to developing teachers' competencies to effectively integrate technology into learning, the development of teachers' awareness of the value of technology-integrated learning is equally important (Carden et al., 2020; Johnson and Jolly, 2017). The general awareness theory explains the tendency of individuals to exhibit various behaviors, such as environmental awareness, cognitive awareness, and self-awareness (Bandura, 1997). When individuals become aware, they tend to develop self-understanding and show a propensity to seek and engage in personal growth (Dweck, 2006). They practice what they perceive as valuable, which may become habitual or normative, and they build positive relationships with others (Brown and Ryan, 2003). Even the Technology Acceptance Theory (TAT) explains that technology acceptance is influenced by perceived benefits and perceived ease of use (Davis, 1989; Soeprijanto et al., 2021). Therefore, the development of teachers' learning management skills in innovative educational settings is directly related to their awareness of technology-integrated learning.

Previous research studies have shown advancements in raising teachers' awareness of transformative learning practices through the Technological Pedagogical and Content Knowledge (TPACK) framework. Koh et al. (2015) have compiled research findings related to the use of TPACK in teacher development, indicating that TPACK can enhance teachers' confidence in technology integration and improve instructional effectiveness. Kaçar (2022) developed pre-service English as a Foreign Language (EFL) teachers in Turkey with digital material designer characteristics using the TPACK framework, resulting in higher overall TPACK scores and increased awareness of integrating technology and content into teaching. Qasem and Viswanathappa (2016) developed science teachers using a blended learning approach, combining face-to-face and online learning, to enhance TPACK. The research findings demonstrated not only higher TPACK development compared to the control group but also increased awareness of technology integration in the classroom. Lu (2014) developed professional education for students to promote TPACK-based technology-integrated learning management. The analysis of journal content revealed increased awareness and appreciation for designing and developing instruction that links with technology use. Additionally, Niess (2005) studied the use of TPACK-oriented science teacher development programs, which fostered abilities in technology-integrated learning management. The research demonstrated that teachers had good TPACK assessment results, increased confidence in instructional design, and recognized the value of technology integration. Chen and Jang (2014) investigated how Taiwanese teachers' concerns about technology integration are connected to their technological, pedagogical, and content knowledge. The finding could provide insights into how teachers' concern about technology adoption influences their readiness and effectiveness in integrating technology into their teaching processes. Understanding these interrelationships could help education policymakers and school administrators design better professional development programs and support systems to enhance teachers' TPACK and facilitate successful technology integration in the classroom. Chee et al. (2017) raised awareness about the importance of continuous professional development for Malaysian preschool teachers that focuses on understanding content, pedagogical knowledge, and applying developmentally appropriate practices in teaching.

2.3. Technological pedagogical and content knowledge (TPACK)

The use of technology in teaching does not necessarily mean that all types of technology must be employed in the classroom. However, teachers who are knowledgeable about utilizing technology should select the appropriate technology that aligns with their teaching objectives and suits the characteristics of their students (Angeli and Valanides, 2009; Koehler and Mishra, 2009). This insight is drawn from a review of over 3,200 research documents that connect the concept of Technological Pedagogical and Content Knowledge (TPACK) with teacher pedagogical competence (Eshelman and Hogue, 2023). TPACK refers to the concept of integrating teachers' knowledge and skills to enhance learning management that effectively utilizes technology in both teaching and students' learning, aiming to achieve learning outcomes and advanced academic skills, as well as fostering digital literacy for self-directed knowledge-seeking and creation. TPACK consists of three essential components (Ertmer and Ottenbreit-Leftwich, 2010; Harris and Hofer, 2011; Koehler and Mishra, 2009): 1) Content Knowledge (CK) refers to the knowledge of the subject matter to be taught, such as knowledge of science, mathematics, etc., 2) Pedagogical Knowledge (PK) refers to the knowledge of teaching methods, such as instructional strategies, assessment techniques, etc., and 3) Technological Knowledge (TK) refers to the knowledge of using technology in teaching, such as using software or tools relevant to instruction. When teachers possess knowledge in all three aspects and integrate them effectively, it promotes the development of other abilities as well.

Developing teachers with TPACK in the education sandbox can help them acquire knowledge and understanding of how to effectively use technology in teaching, increasing their confidence in using technology for instruction. Furthermore, developing teachers with TPACK enables them to design and create engaging and effective instructional media. It also promotes a constructivist approach to learning and fosters students' interest in learning.

Technology-integrated learning began to receive significant attention in terms of its clear relationship with teacher development around the year 2010, and this trend has continued to grow (Dewi et al., 2021; Irwanto, 2021). It refers to a level of learning that includes technology as an integral component of the learning process, rather than solely for the purpose of improving engagement, but to promote learning and develop various skills of learners (Means et al., 2013; Picciano, 2002). The use of technology is introduced not just to make learning enjoyable but to foster a creative learning environment and provide constant access to resources (Gao et al., 2013). It also facilitates effective communication and creates a productive learning space. This approach can be applied across various subjects such as mathematics, science, English, and arts. In general, learners experience diverse and creative learning opportunities, leading to the development of problem-solving, critical thinking, and creativity skills in a more effective manner. The levels of technology integration can be classified according to the Technology Integration Matrix (TIM) developed by the FCIT (2019). The process of technology integration in education can be categorized into five distinct levels: 1) Entry Level: At this stage, technology is used in a basic and limited manner. Teachers may employ tools like presentations or educational software with minimal interaction, 2) Adoption Level: Teachers progress to using technology more effectively, incorporating it into instruction and activities to enhance learning experiences, 3) Adaptation Level: Technology is integrated into a broader range of instructional methods, providing teachers with more flexibility and diverse teaching strategies, 4) Infusion Level: Here, technology becomes an integral part of the learning process. Students actively engage with technology tools to create, collaborate, and solve problems and 5) Transformation Level: The highest level of technology integration, where technology is seamlessly woven into the curriculum, fostering transformative learning experiences and innovative teaching approaches.

The main objective of this research is to study the outcomes of developing science teachers to acquire skills and awareness in integrating content, teaching methods, and technology in their instructional practices. The focus of this study is on teachers in innovative educational settings who play a direct role in the development of youth at the forefront of Thailand's important future direction.

3. Research method

3.1. Participants

An example of the research is a study conducted with 68 voluntary participants who are teachers in innovative educational institutions in Chiang Mai Province, Thailand. The teachers willingly registered to participate in the research and received explanations regarding their involvement in accordance with the requirements of the Office of the Human Research Ethics Committee, Chiang Mai University, as stated in Form AF 02-07. They also signed a letter of consent to participate in the research, as indicated in Form AF 03-07, through the Lifelong Education Platform of Chiang Mai University. Most of the participating teachers had an average age of 35.34 years (ranging from 23 to 55 years) and were predominantly female (80%). They held a bachelor's degree (56%) and did not have a higher academic rank (44%). Additionally, 52% of them were responsible for teaching general science subjects, and they had an average teaching experience of 9.21 years (ranging from 1 to 31 years).

3.2. Research instrument and data collection

The self-perception questionnaire regarding the integration of content knowledge, teaching methods, and technology consists of 20 items, using a 5-point Likert scale (ranging from 1, indicating minimal practice, to 5, indicating extensive practice). The questionnaire measures the following dimensions: 1) Technological Knowledge (TK) - 3 items (e.g., I can easily learn and use various technologies, I know how to troubleshoot technical problems independently, such as when the computer malfunctions), 2) Pedagogical Knowledge (PK) - 5 items (e.g., I can adapt teaching methods to suit diverse learners, I know how to manage the classroom using technology), 3) Content Knowledge (CK) - 2 items (e.g., I have diverse approaches and strategies to facilitate understanding of the taught content), 4) Technological Pedagogical Knowledge (TPK) - 2 items (e.g., I can select instructional technologies that enhance student participation in learning), 5) Pedagogical Content Knowledge (PCK) - 3 items (e.g., I can demonstrate effective teaching practices to guide learning in school subjects, I utilize different teaching activities to enhance student engagement in learning), 6) Technological Content Knowledge (TCK) - 2 items (e.g., I learn about various technologies that can be used to facilitate students' understanding of the entire content), and 7) Technological Pedagogical Content Knowledge (TPACK) - 3 items (e.g., I can demonstrate teaching practices that integrate pedagogical knowledge, content knowledge, and technology appropriately, I can select technologies used in school to support teaching and student learning). All the questions were reviewed by experts to ensure content validity. The experimental results showed that the item-total correlations (rXY) ranged between 0.690 and 0.863, and the reliability coefficient (α) was found to be 0.975.

The assessment and criteria for technology integration levels based on the TIM (Technology Integration Matrix) framework consist of identifying different learning environments and learning objectives. There are five categories: Active, Constructive, Goal-Directed, Authentic, and Collaborative. On the other hand, the learning levels are divided into five stages: Entry, Adoption, Adaptation, Infusion, and Transformation. Each level is used to develop rubrics for evaluating teachers' lesson plans and instructional videos. These rubrics have been reviewed by experts and tested to assess lesson plans and instructional videos created by non-targeted teachers. The interrater reliability for the rubrics ranged from 0.830 to 0.910.

The self-perception questionnaire on managing technology-integrated science learning is composed of 35 items, using a 5-point Likert scale (ranging from strongly agree/agree = 5 to strongly disagree/disagree = 1). It covers four dimensions: 1) Concerns about technology and its impact on professional and daily life, consisting of 11 items (e.g., I worry that I cannot manage all the necessary technology, I worry about having to change my use of technology), 2) Seeking strategies to enhance knowledge and skills in using technology, consisting of 6 items (e.g., I want to know how to modify or adapt my teaching when integrating technology, I want to change my use of technology based on students' experiences), 3) Building networks to leverage technology benefits in work, consisting of 9 items (e.g., I want to communicate/collaborate with others to enhance technology effectiveness, I want to use technology to improve relationships with other teachers within and beyond subject groups), and 4) Planning self-development in technology application, consisting of 9 items (e.g., I want to know how this technology will be used in the near future, I want to know how to enhance or replace existing technology). All the questionnaire items have been content-reviewed by experts, and the experimental results indicated that the item-total correlation (rXY) ranged from 0.380 to 0.718, with a reliability coefficient (α) of 0.942.

The curriculum for technology-integrated learning for science teachers in innovative schools incorporates a blended learning approach, combining content and blended online learning processes. It aims to provide participating teachers with foundational knowledge, practical skills, and application abilities. The curriculum includes the following content for teaching: Cloud-Based Technology, Telecommunication Technology Tools, Lab Simulation Applications, Cumulative Information and Big Data, Video Processing Technology, Office Applications, Image Processing Technology, Augmented Reality (AR), Tablet and Mobile Phone Applications, and Subject Matter-Specific Technology. These topics are used to design training for teachers in 8 activities. The selection of activities and curriculum adjustment is conducted by a panel of experts consisting of 5 university professors with experience in technology-integrated teaching. The curriculum is reviewed and refined based on expert discussions and evaluations, incorporating feedback and suggestions. According to expert evaluations, the average rating for content appropriateness and usefulness of the curriculum is 4.92. The average rating for training processes is 4.96, while the average rating for learning media and equipment is 4.93. The average rating for assessment and evaluation methods is 4.80. All ratings are on a scale of 5.00. Regarding the instructional videos used in the training, expert evaluations indicate an average content appropriateness rating of 4.90, a technical quality rating of 4.93, and a speaker rating of 5.00. All ratings are on a scale of 5.00.

Teacher development and data collection take approximately three months. It begins with the participants completing pre-training questionnaires to assess their self-awareness regarding technology-integrated content and teaching methods, as well as their awareness of technology-integrated science teaching before the training. They then engage in learning activities 1 and 2: Blended Learning with Technology for Digital Science Classrooms and 10 New Generation Tool Groups for Technology-Integrated Science Learning. These activities are conducted through Asynchronous Online Learning via the Lifelong Education Chiang Mai University platform and consist of 12 instructional videos with a total learning time of 3 hours. Activities 3 to 6 include applications based on cloud technology and visualization apps, following the concept of "Technology-Integrated Science Learning." These activities focus on application-based platforms and conclude with an After-Action Review and Reflection (AARR) using Synchronous Online Learning over a 2-day period. Following this, participants are given a period of 2 months to design and implement their own learning management plans based on the acquired knowledge. Activity 7 involves the application and on-the-job training/coaching and mentoring. It adopts a format of Zoom meetings conducted in 9 rounds, each lasting 1 hour, with 5-8 participants in each round. During this activity, participants provide feedback by completing questionnaires that assess their self-awareness of technology-integrated content and teaching methods, as well as their awareness of technology-integrated science teaching after the training. This activity spans two days. Lastly, Activity 8 involves an expanded network meeting and awareness-building through Zoom-based lectures and exchange activities.

3.3. Data analysis

The data collected from the pre- and post-training questionnaires regarding self-awareness of technology-integrated content and teaching methods were used to determine the level of technology integration based on teachers' perceptions. These data were combined with the evaluation of the learning management plans and instructional videos using the criteria for technology integration levels. A cross-tabulation analysis was then performed to analyze the content from the inquiry found in the learning management plans and instructional videos, explaining the changes in teachers' teaching practices. Additionally, the data from the pre-training and post-training questionnaires on awareness of technology-integrated science teaching were analyzed using descriptive statistics to compare the differences in awareness of instructional practices, complementing the content analysis from the open-ended section of the questionnaire.

4. Result and discussion

4.1. The development of technology-integrated content and teaching methods

The results from two rounds of questionnaire administration indicated an overall improvement in teachers' learning management skills across all aspects. The average scores for each aspect were relatively close both before the training (ranging from 3.405 to 3.477) and after the content training (ranging from 4.061 to 4.212). The aspect that exhibited the highest degree of change was Technological Pedagogical Knowledge (TPK) with a 22.747% increase, followed by Pedagogical Content Knowledge (PCK), with a 20.975% increase, and Pedagogical Knowledge (PK), with a 20.910% increase. Technological Knowledge (TK) showed the lowest degree of change. The researchers observed the standard deviation values, which reflect the dispersion of average scores, before the training (ranging from 0.655 to 0.785) and after the training (ranging from 0.468 to 0.567). It was found that after the content training and practical implementation, not only did the average scores increase, but also the dispersion of skills in managing learning decreased. This indicates that most of the participants had higher and more similar learning management skills, resulting in less variability in skill levels. The details are presented in Table 1.

In addition, when considering the categorization of technology integration levels in learning, using five levels, it was found that before attending the training, most teachers self-assessed their learning management skills at the Adoption level, with 27 individuals (39.71%), closely followed by the Entry level, with 23 individuals (33.82%). This means that more than half of the teachers (73.53%) perceived their learning management skills in technology integration as being at a low or lowest level. Some teachers assessed themselves at the adoption and higher levels (26.47%). After the training, most teachers self-assessed their skills at the Adaption level, with 26 individuals (38.24%), closely followed by the Infusion level, with 24 individuals (35.29%). There were 13 teachers who self-assessed their skills at lower levels: 11 at the Adoption level (16.18%) and two at the Entry level (2.94%). Additionally, five teachers (7.35%) self-assessed themselves at the highest level, Transformation.

In summary, regarding the development of teachers' technology integration skills through training, most teachers showed improvement, advancing approximately 2 to 3 levels from their initial level (Entry to Adoption) to a moderately high level (Adaptation to Infusion). In this research, the researchers observed that there were eight teachers (11.76%) who did not show any improvement in their self-assessment level. Specifically, two teachers remained at the Entry level, three teachers remained at the Adoption level, and another three teachers remained at the adoption level. Details are presented in Table 2.

In addition, when studying the guidelines for integrating technology into instructional design based on the assessment of learning management plans, it was found that teachers tend to use technology in five different ways: 1) Communication: Technology is used for communication, information dissemination, announcements, and displaying scores between teachers and students, as exemplified by tools like Google Meet, Jam board, and Padlet. However, the research findings indicate that the usage in this aspect is still relatively low and has decreased after completing the training, 2) Assessment: Technology is used for measuring, checking understanding, and assessing students' knowledge in various areas. Examples include quiz websites like Quizizz and Kahoot, as well as the website Python.nattapon.com. The research findings suggest that the usage in this aspect is still relatively low, with a stable trend, 3) Multimedia Creation: Technology is used to create multimedia materials for students to engage in practical activities that apply their knowledge. Examples include programming websites like https://code.org and software like Scratch, Python, and WordPress. The research findings indicate that the usage in this aspect is still relatively low, with a stable trend 4) Gamification: Technology is used as a teaching tool to stimulate student participation, enhance thinking and planning skills, and promote group collaboration. Examples include apps like Wordwall, SciKids, EatD, and Gamilab. The research findings suggest that the usage in this aspect is still relatively low, with a stable trend, and 5) Instructional Management: Technology is used as a supplementary tool for instructional activities, learning tasks, practical training to enhance students' expertise, and connect knowledge with real-life applications. Examples include platforms like YouTube, TikTok, Mentimeter, and CircuitLab. The research findings indicate that this aspect has the highest usage of technology among teachers, and it has shown the most significant changes and diversity in technology integration, both before and after training. The details of usage in each aspect before and after training are shown in Table 3.

Table 1: Changes in the assessment of learning management skills in each aspect

Factor of TPACK	Before		After		Rate of change (%)
	Mean	SD	Mean	SD	
TK	3.465	0.726	4.061	0.502	17.201
PK	3.405	0.655	4.117	0.519	**20.910**
CK	3.477	0.709	4.136	0.543	18.953
TPK	3.432	0.722	4.212	0.567	**22.727**
PCK	3.447	0.692	4.170	0.468	**20.975**
TCK	3.477	0.709	4.121	0.512	18.522
TPACK	3.409	0.785	4.101	0.537	20.299

Table 2: Changes in the level of learning management before and after curriculum training

Before	After					Total
	Entry	Adoption	Adaption	Infusion	Transformation	
Entry	2	8	9	4		23
Adoption		3	14	9	1	27
Adaption			3	11	3	17
Infusion					1	1
Transformation						-
Total	2	11	26	24	5	68

Table 3: Technology integration in the teaching practice of teachers before and after training

Categories	Before	After
No usage	(10)	(1)
Classroom Communication	Google Meet (4), Google Classroom (1), Line (1), LiveWorksheets (1), Whiteboard.fi (1) Google Lolab, Padlet (1), Jam board (1)	Google Meet, Line, Google Map (3), Padlet (1), Whiteboard.fi (1), Jam board (2)
Testing	Website Quizizz (1), Kahoot (1), python.nattapon.com (1)	Kahoot (1), Website Quizizz (1)
Creating Teaching Material	Teachers guide students via https://code.org (1)	WordPress (1), Scratch Program (1), Python Program (1)
Gaming	Play games in the Wordwall app via Active (1)	SciKids app (1), EatD app (1), Gamilab app (1)
Teaching Management	PowerPoint (17), Video or YouTube (17) Listening to music/clip (2), Internet Research (2), TikTok clip (2), phET app (2), Star Walk app (1), Mentimeter (1), Gizmos app (1)	PowerPoint (8), Video or YouTube (8), phET media (3), smartphone QR code scan (2), Jam board (1), Mentimeter (1), Walter-fendt.de website (1), Merge Cube media (1), Quivervision app (1), Live worksheets, Word wall website (1), Lux Meter app (1), Circuit Lab (1), TikTok clip (1), Gene Screen app (1), PEA Smart Plus app (1), Wheel of Names app (1), AR app (1), SciMath simulation (1)

Note: The numbers in parentheses indicate the number of lesson plans

4.2. The shift in awareness of integrated management of learning through the integration of content, teaching methods, and technology

The results of self-assessment on awareness revealed that teachers had concerns regarding the integration of technology and the outcomes resulting from its use after training (2.741), which decreased from the pre-training phase (3.266). However, there were positive changes observed in three aspects. Firstly, teachers actively sought ways to enhance their knowledge and skills in utilizing technology after training (3.735), compared to before training (3.387). Secondly, teachers engaged in networking to leverage technology for work purposes after training (4.116), compared to before training (3.560). Lastly, teachers showed a greater inclination towards planning self-development in terms of applying technology to improve the quality of learning management after training (4.003) compared to before training (3.510). Additionally, the researchers noted that the standard deviation values of self-assessment scores in each aspect indicated that the teachers' awareness, in general, was closely aligned after training (ranging from 0.220 to 0.449) and relatively similar to the pre-training phase (ranging from 0.319 to 0.448). This suggests that the training program had a positive impact on the teachers' awareness, resulting in a clearer reduction in anxiety and improved trends in their awareness of technology integration. The details are presented in Table 4.

From the above research findings, the researchers have identified four important points of discussion. Firstly, the development of teachers in all aspects is influenced by important factors such as intrinsic motivation, which increases their knowledge base through personalized learning (Demink-Carthew et al., 2020). Trainees have the intention to acquire new knowledge and are eager to experiment with the knowledge gained during the training in their actual classrooms under the guidance of a team of facilitators. They can conveniently seek advice and address various problems while applying their knowledge in their own classrooms. Teachers in this context are cognizant of their pivotal role in driving transformative changes in the country's education system. This awareness provides them with clear goals, inspiration, and a strong sense of enthusiasm to strive for success (Soeprijanto et al., 2021). Furthermore, they are receptive to new learning opportunities that aid in their professional development and advancement (Deci and Ryan, 2000; Means et al., 2013; Park et al., 2020; Sternberg, 2003). Such learning experiences are expected to lead them toward progress and excellence in their careers.

Table 4: Awareness of teachers from training participation

Awareness	Before		After	
	Mean	SD	Mean	SD
1. Concerns about technology and its impact on professional and daily life	3.266	0.448	2.741	0.449
2. Seeking ways to enhance knowledge and skills in technology use	3.387	0.319	3.735	0.220
3. Networking for leveraging technology in work	3.560	0.388	4.116	0.326
4. Planning self-development in applying technology to learning	3.510	0.346	4.003	0.310

Secondly, the researchers observed the most significant changes in the components, with PK being the most prominent, including CPK, TPK, and PK. This may be due to the content and processes in the teacher training curriculum, which emphasize hands-on teaching techniques coupled with the use of various technologies. The focus is not on the content that teachers are familiar with in their normal teaching practices. As a result, teachers perceive the most significant changes in the aforementioned components. This aligns with the intention of using TPACK, which does not emphasize the development of knowledge in a single dimension but focuses on the application of knowledge in hands-on teaching practices and creative integration of technology (Angeli and Valanides, 2009; Gao et al., 2013; Koehler and Mishra, 2009). When teachers receive training and share experiences in both face-to-face and online formats that facilitate practical application and real-world learning (Qasem and Viswanathappa, 2016), it leads to the most prominent development in the pedagogy and content components. This also results in an upward shift in the assessment of technology integration into teaching practices.

Thirdly, the research findings indicate that teachers have developed and diversified their use of instructional technology formats more than before participating in the training. These results can be explained by the linkages with previous research that shows that using TPACK can help teachers gain confidence in their instructional design and management (Niess, 2005). It creates awareness that changing teaching strategies is not beyond their abilities, and they are willing to implement them more in their learning management culture (Koh et al., 2015; Wang et al., 2014). This includes developing an awareness to seek new tools and expand their network of teacher peers, as well as reducing anxiety (Davis, 1989; Dweck, 2006; Qasem and Viswanathappa, 2016).

Finally, the researchers have made observations regarding the diversity of formats and types of technology usage in teaching, both before and after training. This diversity aligns with previous research findings on technology use in the classroom, including its use for testing or assessing students, classroom management, efficient instructional media usage, and bridging learning gaps among students (Eshelman and Hogue, 2023; Gozukucuk and Gunbas, 2022; Kara, 2021). However, a notable difference lies in the fact that teachers who underwent training had the option to incorporate popular entertainment-oriented technology media that are trending among students, such as TikTok, YouTube, and the PEA Smart Plus app. The researchers believe that this serves as a smart and creative way to engage students' interests. Yet, differences in teaching strategies and learning outcomes were observed. The utilization of technology in teaching still appeared to be at a superficial level, and reflection on peer feedback for more precise student development was lacking. Effective group processes were also underutilized. These components are seen as crucial for enhancing the full potential of technology usage (Sun et al., 2022; Wang, 2021). Nevertheless, the researchers believe that the group of teachers participating in the study can continue to develop and enhance their teaching abilities in these areas. This is because the transition to using technology effectively is a gradual process, and they are now becoming more aware of its potential in teaching and are in the process of integrating it into their teaching methods, which may require some time for experimentation and adjustment (Fink et al., 2023).

5. Conclusion and discussion

This research study has yielded important conclusions. Firstly, teachers who participated in the training on Technology Pedagogy and Content Knowledge (TPACK) showed development in each aspect, ranging from 17.201% to 22.727%. The aspect that exhibited the highest development was Technological Pedagogical Knowledge (TPK), followed by Pedagogical Content Knowledge (PCK) and Pedagogical Knowledge (PK), respectively. The aspect with the least development was Technological Knowledge (TK). Furthermore, there was a significant trend among teachers towards increased integration of technology in instructional design, progressing from the levels of Entry to Adoption (73.53%) to the levels of Adaption to Infusion (73.53%). Additionally, the trend of technology primarily involved using it as a medium for instructional management. It was also utilized for communication, knowledge assessment, creating instructional materials, and incorporating educational games into teaching practices. Secondly, most teachers showed an improved awareness of integrating content with technology in their instructional practices. They actively sought new technological networks to benefit instructional design activities. They planned their work to develop teaching practices that could apply technology more extensively. They sought ways to enhance their knowledge and expertise in utilizing technology in teaching and learning. Furthermore, their concerns about the current use of technology and its impacts significantly decreased.

Overall, these findings indicate that teachers are increasingly embracing the integration of content and technology in their teaching practices. They actively seek new technological networks to enhance instructional design activities. They plan their work to develop teaching practices that can more effectively apply technology. They seek ways to enhance their knowledge and skills in utilizing technology in teaching. Moreover, their concerns about current technology use and its impacts have significantly diminished.

6. Implementation

This research study has provided significant recommendations for utilizing the research findings. The four key points are as follows: Firstly, the development of teachers' skills in managing technology-integrated learning should be approached using the TPACK model. It should begin by fostering intrinsic motivation and the desire for self-improvement to utilize knowledge in practical responsibilities. This will enable teachers to have clear goals in participating in training and collaborate in their self-development plans throughout the training period. Secondly, the design of activities, media, and training materials should be well-prepared. They should be organized and subdivided into concise and easily comprehensible units, with examples and demonstrations. Additionally, providing self-review materials and self-directed learning processes at any time would be beneficial. Importantly, teachers should receive feedback on the results of their actual practice at least once. Thirdly, in cases where participating teachers have different technological backgrounds and abilities, researchers should assess the level of technology-integrated learning to facilitate the development of teachers with diverse foundations. This assessment can be used to refine the details of the process, such as the demonstration steps, as well as to provide recommendations for teachers, enabling them to fully develop their potential and promote more flexible innovations in teacher development. Lastly, developing teachers through online platforms is a format and approach that aligns with the working patterns and lifestyles of society. It allows teachers to utilize their free time beyond their demanding responsibilities. It can be considered as a means of promoting lifelong learning for teachers. Therefore, future research should focus on collecting issues, problems, or questions arising from self-development following the TPACK framework by teachers, as well as researchers' recommendations for teachers. This will contribute to the development of an intelligent advisory system, which will enhance the completeness of the teacher development system.

Acknowledgment

The researchers would like to express gratitude to the Faculty of Education, Chiang Mai University, for providing the funding that supported the dissemination of this research.

Compliance with ethical standards

Conflict of interest

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

References

Angeli C and Valanides N (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK). Computers and education, 52(1): 154-168. https://doi.org/10.1016/j.compedu.2008.07.006

Bandura A (1997). Self-efficacy: Theory exercise of control. W. H. Freeman and Company, New York, USA.

Baris MF (2015). European teachers' technological pedagogical content knowledge (TPCK) and educational use of web technologies. European Journal of Educational Research, 4(4): 149-155. https://doi.org/10.12973/eu-jer.4.4.149

Bates AW (2015). Teaching in a digital age: Guidelines for designing teaching and learning. BCcampus, Victoria, Canada.

Boyd D (2014). It's complicated: The social lives of networked teens. Yale University Press, New Haven, USA.

Brown KW and Ryan RM (2003). The benefits of being present: Mindfulness and its role in psychological well-being. Journal of Personality and Social Psychology, 84(4): 822-848. https://doi.org/10.1037/0022-3514.84.4.822 **PMid:12703651**

Carden J, Jones RJ, and Passmore J (2022). Defining self-awareness in the context of adult development: A systematic literature review. Journal of Management Education, 46(1): 140-177. https://doi.org/10.1177/1052562921990065

Chee J, Mariani MN, Othman AJ, and Nor Mashitah MR (2017). Understanding the content pedagogical knowledge among preschool teachers and application of developmentally appropriate practices in teaching. International Journal of Advanced and Applied Sciences, 4(3): 148-153. https://doi.org/10.21833/ijaas.2017.03.023

Chen YH and Jang SJ (2014). Interrelationship between stages of concern and technological, pedagogical, and content knowledge: A study on Taiwanese senior high school in-service teachers. Computers in Human Behavior, 32: 79-91. https://doi.org/10.1016/j.chb.2013.11.011

Davis FD (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 13(3): 319-340. https://doi.org/10.2307/249008

Deci EL and Ryan RM (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. Psychological Inquiry, 11(4): 227-268. https://doi.org/10.1207/S15327965PLI1104_01

DeMink-Carthew J, Netcoh S, and Farber K (2020). Exploring the potential for students to develop self-awareness through personalized learning. The Journal of Educational Research, 113(3): 165-176. https://doi.org/10.1080/00220671.2020.1764467

Dewi NR, Rusilowati A, Saptono S, Haryani S, Wiyanto W, Ridlo S, and Atunnisa R (2021). Technological, pedagogical, content knowledge (TPACK) research trends: A systematic literature review of publications between 2010-2020. Journal of Turkish Science Education, 18(4): 589-604. https://doi.org/10.36681/tused.2021.92

Dweck CS (2006). Mindset: Theory new psychology of success. Random House, New York, USA.

Ertmer PA and Ottenbreit-Leftwich AT (2010). Teacher technology change: How knowledge, confidence, beliefs, and culture interest. Journal of Research on Technology in Education, 42(3): 255-284. https://doi.org/10.1080/15391523.2010.10782551

Eshelman TC and Hogue M (2023). Pre-service teacher perceptions on TPACK instructional design micro-course: A case study in the northeastern United States. TOJET: The Turkish Online Journal of Educational Technology, 22(1): 161-180.

ESMO (2019). The Royal Gazette disseminates the announcement of the committee on educational innovation policy's criteria for evaluating performance and management in educational innovation areas in the year 2021. Education Sandbox Management Office. Available online at: https://moe360.blog/2021/12/23/education-sandbox-2/

FCIT (2019). The technology integration matrix. Florida Center for Instructional Technology. Available online at: https://fcit.usf.edu/matrix/matrix/

Fink A, Spoden C, and Frey A (2023). Determinants of higher education teachers' intention to use technology-based exams. Education and Information Technologies, 28(6): 6485-6513. https://doi.org/10.1007/s10639-022-11435-4 **PMid:36415780 PMCid:PMC9670063**

Gao F, Zhang T, and Franklin T (2013). Designing asynchronous online discussion environments: Recent progress and possible future direction. British Journal of Educational Technology, 44(3): 469-483. https://doi.org/10.1111/j.1467-8535.2012.01330.x

Gozukucuk M and Gunbas N (2022). Preservice teachers' design of technology-based reading texts to improve their TPACK. Journal of Education, 202(1): 92-102. https://doi.org/10.1177/0022057420966763

Harris J and Hofer M (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. Journal of Research on Technology in Education, 43(3): 211-229. https://doi.org/10.1080/15391523.2011.10782570

Irwanto I (2021). Research trends in technological pedagogical content knowledge (TPACK): A systematic literature review from 2010 to 2021. European Journal of Educational Research, 10(4): 2045-2054. https://doi.org/10.12973/eu-jer.10.4.2045

Kaçar IG (2022). Pre-service ELF teachers as digital material designers: A case study into the TPACK development in the Turkish context. Teaching English with Technology, 22(3/4): 107-130.

Kara S (2021). An investigation of technological pedagogical and content knowledge (TPACK) competencies of pre-service visual arts teachers. International Journal of Technology in Education, 4(3): 527-541. https://doi.org/10.46328/ijte.184

Koehler MJ and Mishra P (2009). What is technological pedagogical content knowledge? Contemporary Issues in Technology and Teacher Education, 9(1): 60-70.

Koh JHL, Chai CS, Benjamin W, Hong HY, and Lim WY (2015). Technological pedagogical content knowledge (TPACK) and design thinking: A framework to support ICT lesson design for 21st century learning. Asia-Pacific Educational Research, 24(3): 535-543. https://doi.org/10.1007/s40299-015-0237-2

Kokandy R (2021). Teachers' perceptions of using digital gaming in classrooms. International Journal of Educational Technology and Learning, 11(1): 6-13. https://doi.org/10.20448/2003.111.6.13

Lu L (2014). Cultivating reflective practitioner in technology preparation: Constructing TPACK through reflection. Education Science, 4(1): 13-35. https://doi.org/10.3390/educsci4010013

Mangkhang C, Yimsawat C, Nettip A, and Kaewpanya N (2021). Area-based learning approach to the competency development of social studies pre-service teacher in the Chiangmai education sandbox area, Thailand. Journal of Education and e-Learning Research, 8(3): 264-271. https://doi.org/10.20448/journal.509.2021.83.264.271

Means B, Toyama R, Murphy R, and Baki M (2013). The effectiveness of online and blended learning: A meta-analysis of the empirical literature. Teachers College Record, 115(3): 1-47. https://doi.org/10.1177/016146811311500307

Niess ML (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. Teaching and Teacher Education, 21(5): 509-523. https://doi.org/10.1016/j.tate.2005.03.006

Palomino MDCP, Medina-Garcia M, and Higueras-Rodriguez L (2020). Analysis of initial teacher training for the European area: A key instrument of social transformation. Journal of Education and e-Learning Research, 7(3): 277-284. https://doi.org/10.20448/journal.509.2020.73.277.284

Park MH, Riley JG, and Branch JM (2020). Developing self-awareness using mindfulness meditation with preservice teachers: Reflections on practice. Journal of Early Childhood Teacher Education, 41(2): 183-196. https://doi.org/10.1080/10901027.2019.1695692

Picciano AG (2002). Beyond student perceptions: Issues of interaction, presence, and performance in online course. Online Learning Journal, 6(1): 21-40. https://doi.org/10.24059/olj.v6i1.1870

Qasem AAA and Viswanathappa G (2016). Blended learning approach to develop the teachers' TPACK. Contemporary Educational Technology, 7(3): 264-276. https://doi.org/10.30935/cedtech/6176

Shirky C (2010). Cognitive surplus: Creativity and generosity in a connection age. Penguin, London, UK.

Soeprijanto S, Diamah A, and Rusmono R (2022). The effect of digital literacy, self-awareness, and career planning on engineering and vocational teacher education students' learning achievement. Journal of Technology and Science Education, 12(1): 172-190. https://doi.org/10.3926/jotse.1434

Spours K, Hodgson A, Grainger P, and Smith D (2020). Area-based reviews and their aftermath: Moving to a post-incorporation model for further education in England? Journal of Vocational Education and Training, 72(3): 350-374. https://doi.org/10.1080/13636820.2019.1607534

Sternberg RJ (2003). Wisdom, intelligence, and creativity synthesized. Cambridge University Press, Cambridge, UK. https://doi.org/10.1017/CBO9780511509612

Sulistiani IR, Setyosari P, Sa'dijah C, and Praherdhiono H (2024). Technological pedagogical content knowledge of preservice elementary teachers: Relationship to self-regulation and technology integration self-efficacy. European Journal of

Educational Research, 13(1), 159-170. https://doi.org/10.12973/eu-jer.13.1.159

Sun J, Ma H, Zeng Y, Han D, and Jin Y (2022). Promoting the AI teaching competency of K-12 computer science teachers: A TPACK-based professional development approach. Education and Information Technologies, 28(2): 1509-1533. https://doi.org/10.1007/s10639-022-11256-5

Suwanmanee S, Wannapairo S, Chumruksa C, Kasinan C, Prasitpong S, Sae-Tae K, Benjasri W, Yaodum T, Di-Sawat M, Klaithong P, Kaeopheng W, and Pisitphunphorn J (2023). Transformational leadership development for school administrators emphasizing area potential with learners' science, math, and technology competencies in education sandbox, Thailand. Cogent Social Sciences, 9(1): 2179740. https://doi.org/10.1080/23311886.2023.2179740

UN (2015). Sustainable development goal: SDGs. United Nations, New York, USA.

Wang CX (2021). CAFE: An instructional design model to assist K-12 teachers to teach remotely during and beyond the COVID-19 pandemic. Techtrends, 65(1): 8-16. https://doi.org/10.1007/s11528-020-00555-8 **PMid:33169121 PMCid:PMC7609383**

Wang L, Ertmer PA, and Newby TJ (2014). Increasing preservice teachers' self-efficacy beliefs foe technology integration. Journal of Research on Technology in Education, 36(3): 231-250. https://doi.org/10.1080/15391523.2004.10782414