Integrating TPACK in a Pre-Service Teachers' EFL Course: Impacts on Perception, Knowledge, and Practices

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Abstract: Most research that has explored integrating the Technological Pedagogical Content Knowledge (TPACK) framework into teacher education programs primarily utilized context-unspecific self-report instruments. This mixed-methods study explored the efficacy of integrating four domains of the TPACK framework in an EFL course on the perception and knowledge of (30) pre-service teachers in an Egyptian university. The study also investigated the effect of the TPACK-based course on participants' lesson plans and teaching practices. Data collection instruments included a test, a questionnaire, observation checklists, lesson plans, and semi-structured interviews. Quantitative analysis showed that pre-service teachers' knowledge and perception of PCK, TCK, TPK, and TPCK have significantly improved after the course. Qualitative analysis of participants' lesson plans, observation, and interviews revealed that participants moderately integrated technologies in their instruction and PCK was the most dominant in their teaching. The study provided implications for implementing TPACK in teachers' education programs.

Keywords: TPACK, pre-service EFL teachers, perceptions, teacher knowledge, practices.

Introduction

Teacher preparation programs influence teachers' knowledge, attitudes, and self-confidence in integrating technologies in the classroom (Agustin & Liliasari, 2017; Tseng et al., 2019). Angeli and Valanides (2014) highlight the importance of empowering pre-service teachers with entry-level knowledge concerning selecting technology, content, and pedagogy. However, teacher preparation programs in most faculties of education in Egyptian universities still focus on delivering academic and pedagogical courses separating the technological knowledge. This creates a dichotomy between content knowledge and pedagogy (Elbehary, 2020). Although microteaching sessions are supposed to provide pre-service teachers with opportunities to practice instructional methods with their peers in artificial settings, many pre-service teachers reported that these sessions often focus on content and neglect the school curriculum (Hamada, 2014).

Technological Pedagogical Content Knowledge (TPACK), an extension of Shulman's (1986) Pedagogical Content Knowledge (PCK) model, was developed by Mishra and Koehler (2006) to aid teachers and researchers in understanding the relationship among technology, content, and pedagogical approaches. TPACK is considered the most functional model to assess teachers' expertise in terms of technology integration (Mishra & Koehler, 2006).

According to Yurdakul et al. (2012), TPACK is a framework that describes teachers' technological and techno-pedagogical knowledge and skills to enact technology. TPACK guarantees that digital tools are integrated as an integral part of the instructional design process and emphasizes the interactions between pedagogy, content, and technology.

On the one hand, most research that has explored the integration of the Technological Pedagogical Content Knowledge (TPACK) framework into teacher education programs primarily utilized context-unspecific self-report instruments. Voogt et al. (2013) noted that empirical studies that addressed TPACK focused mostly on exploring teachers' beliefs, pre-service teachers' TPACK level, and ways to enhance in-service teachers' use of TPACK. Few studies investigated the use of the TPACK model as a theoretical framework for designing professional development or teacher preparation programs (Dysart & Weckerle, 2015). This issue needs to be adequately addressed as the latest review study (articles 2012-2022) concluded that the reviewed studies mostly used qualitative data and mainly focused on in-service teachers (Luo & Zou 2022).

On the other hand, recent Egyptian initiatives like "Teachers First" aim to prepare teachers and school administrators with knowledge of emerging technologies to improve their technology implementation in schools (Mogheith et al., 2019). Besides, the strategic plan of Egypt Vision 2030 regarding teachers' preparation and development was modified to cope with recent changes. "Teachers in 2030 may be more curious and innovative, with social interest and strong technical skills, and they become an excellent example of learning and creativity, and they will evolve to the professional standard of work, as someone who teaches himself, and someone who helps others learn" (Singer & El-Farahaty, 2020, p.13).To achieve this goal, the researchers in the current study attempted to examine the effect of integrating the TPACK model in an EFL course delivered to pre-service teachers in Egypt to explore their perceptions and knowledge of TPACK and their integration of the model in their instructional practices.

Literature Review

Theoretical Background

The TPACK model is an extension of Shulman's (1986) Pedagogical Content Knowledge taxonomy in which teachers combine Pedagogical Knowledge (PK), Content Knowledge (CK), and Technological Knowledge (TK). Later, Mishra and Koehler (2006) added three hybrid components that show an interaction of the first three elements to include seven factors: Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Knowledge (TK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), Technological Content Knowledge (TCK), and Technological Pedagogical Content Knowledge (TPCK).

Koehler et al. (2005) created the first phase of TPACK research to interrelate content, pedagogy, and technology. The second phase investigated the effect of professional development on teachers' enactment of TPACK (Doering, et al., 2009; Jang, 2010). In the third phase, several studies have explored the relationship among TPACK components and the impact of each component separately (Wilson & Wright, 2010). However, few studies focused on TPACK as a unified body (Archambault & Crippen, 2009). Figure 1 represents the TPACK framework and the interrelation among the seven components.

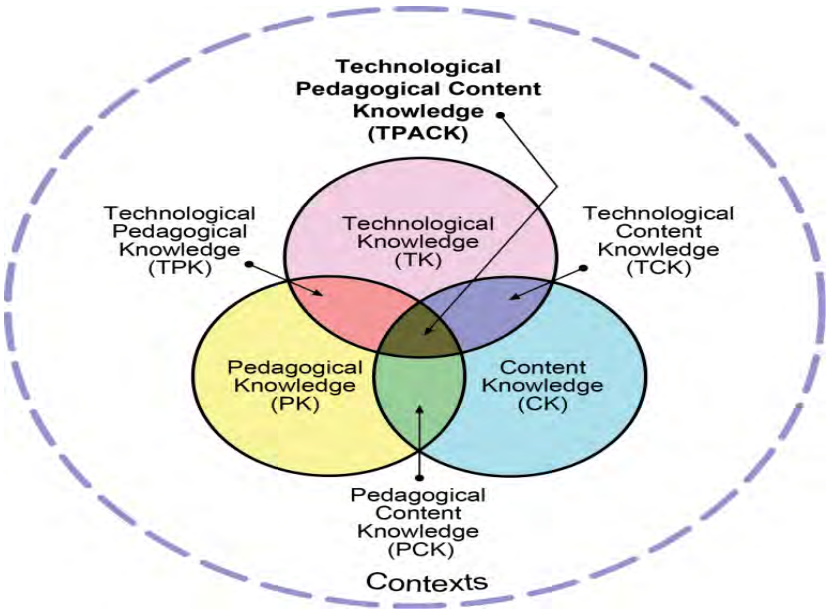

Figure 1. TPACK framework and its components (source: http://tpack.org/). Reproduced by permission of the publisher, © 2012 by tpack.org.

Content Knowledge (CK) refers to teachers' knowledge of topic-specific content and subject matter. CK includes teachers' ability to organize and present content concepts. Pedagogical Knowledge (PK) comprises knowledge of teaching methodologies and pedagogical activities (e.g., lesson plans, teaching methods, and assessment and classroom management). Moreover, Technological Knowledge (TK) encompasses information technology knowledge to use and adapt emerging technologies in education and create various tasks by integrating technology.

Pedagogical Content Knowledge (PCK) indicates the knowledge of presenting the subject matter to meet students' needs and background knowledge to promote instructional practices in the content areas. Technological Content Knowledge (TCK) reflects teachers' ability to select and employ emerging technologies to represent specific subject matter. Technological Pedagogical Knowledge (TPK) includes "knowing the pedagogical affordances and constraints of a range of technological tools as they relate to disciplinarily and developmentally appropriate pedagogical designs and strategies" (Koehler & Mishra, 2009, p.65). TPK refers to the contribution of technological knowledge to improving representations of specific content and students' understanding of content areas. Koehler and Mishra (2009) define Technological Pedagogical Content Knowledge (TPACK) as the knowledge of representing subject-specific topics using effective emerging technologies and pedagogical techniques. TPACK encompasses understanding the impact of specific technologies on learning and teaching processes, which is the outcome of the interaction among content, pedagogy, and technology knowledge.

Assessment of TPACK

TPACK measures can be classified into self-report and performance-based tools (Fisser et al., 2015). Questionnaires and interviews generate self-report data, while lesson plans and observation assess performance-based behaviors. Being the most common measures for assessing TPACK, self-assessment scales were developed to be more context-specific to certain subject matters. Although self-report questionnaires collect data from big

samples quickly, they are ineffective in gathering unbiased and representative responses. Therefore, self-reports are criticized for focusing on assessing confidence more than practical knowledge (Willermark, 2018). Additionally, Koehler et al. (2012) assume that the majority of TPACK self-report questionnaires were invalid and unreliable and assess some components such as TK, PCK, and TPCK assessed by Archambault and Barnett (2010) and the T-components evaluated by Scherer et al. (2017).

Tseng (2014) developed an EFL TPACK questionnaire to assess EFL teachers' TPACK. Baser et al. (2016) also created a valid survey to evaluate EFL teachers' TPACK. The two surveys display the same factor structure as the general seven-dimension TPACK model. One commonly used survey is Schmidt et al. 's (2009) TPACK survey, which was developed and validated by many researchers to assess pre-service teachers' perceptions of TPACK during an instructional technology course. Bostancıoğlu and Handley (2018) created a valid and reliable English as a Foreign Language-TPACK (EFL-TPACK) questionnaire for EFL contexts. Hence, the present study adapted this questionnaire to suit the EFL setting.

Besides self-reports, some researchers developed external assessment tools to provide in-depth data about TPACK practices, including analysis of behaviors and instructional artifacts (Rahimi & Pourshahbaz, 2019). External assessment, like portfolios, lesson plans, interviews, and observations, depends on qualitative techniques to examine TPACK. Additionally, Aktaş and Özmen (2020) and Kwangsawad (2016) assessed lesson plans for TPACK. Lyublinskaya and Tournaki (2013) created a rubric to assess pre-service teachers' TPACK following Niess' schema for technology integration.

Schmid et al. (2020) recommend that future studies explore TPACK assessment tools that measure specific subjects or content. They also suggest that various tools must be used to triangulate self-report data, including observations, lesson plans, or performance assessments to eliminate biases. Similarly, Harris et al. (2010) argued that for a better understanding of TPACK, various measurement tools must be utilized. As a result, in the current study, TPACK perception and knowledge were assessed by a self-report questionnaire and a cognitive test. In contrast, TPACK practices were assessed via performance assessment (lesson plans, observations, and interviews).

EFL TPACK

Based on the TPACK model and due to the urgent need to integrate technology into the EFL curriculum, Rahimi and Pourshahbaz (2019) proposed a TPACK framework that suits EFL contexts and includes knowing and understanding theoretical frameworks of CALL and its applications in teaching English skills (listening, speaking, reading, and writing) and sub-skills (vocabulary, pronunciation, grammar). Using ICT-rating and TPACK scales, Rahimi and Pourshahbaz (2016) investigated teachers' TPACK in EFL classes regarding design, exertion, ethics, and performance. Table 1 represents the EFL TPACK model.

EFL TPACK domains	Definition	Example
CK	Knowledge of the subject matter without consideration about teaching the subject matter	English language proficiency
PK	Knowledge about the students' learning, instructional methods, different educational theories, and learning assessment to teach a subject matter without references towards content	Knowledge of generic teaching strategies, beliefs and practices, along with support knowledge, the knowledge of the various disciplines that would enrich teachers' approach to the teaching and learning of English (e.g., educational psychology, second language acquisition), such as knowledge of using metacognitive strategies to enhance learning
PCK	Knowledge of representing content knowledge and adopting pedagogical strategies to teach English	The specialized knowledge of language teaching and learning; how to represent English as a foreign language in the classroom and how language learners come to understand English in the context of real teaching; discovering the students' problems and ways to overcome those problems by considering all variables related to their language learning (teaching materials, assessment procedures, parents, etc.), such as knowledge of conducting group activities to improve students' learning
TK	Knowledge about how to use ICT hardware and software and associated peripherals	IT literacy, knowledge of technology in general, knowing about basic computer applications (software), devices (printers, scanners, digital cameras), and environment (www)
TPK	Knowledge of the existence and specifications of various technologies to enable teaching approaches without reference towards the subject matter	IT integration literacy, the ability to use technologies to teach and interact with Students
TCK	Knowledge about how to use technology to represent/research and create the content in different ways without consideration about Teaching	Knowledge of CALL at the level of technology use and content preparation
TPACK	Knowledge of using various technologies to teach, represent, and facilitate knowledge creation of specific subject content	Knowledge of CALL teaching /learning: using multimedia software /games as a tool to enrich teaching language macro skills (listening, speaking, reading, writing) and components (grammar, vocabulary, pronunciation); class management and assessing students' learning; presenting content via appropriate language teaching strategies by using proper technological tools intermingled with appropriate language teaching methodology/ instructional materials

Table 1. EFL TPACK Components (Adopted from Rahimi & Pourshahbaz, 2019, p.145)

TPACK and Teaching Practices

Researchers investigated the effect of TPACK on pre-service teachers. It was found that EFL TPACK had significantly predicted more than a quarter of ICT use in EFL classes. Ersanli (2016) explored the impact of a five-week workshop on the TPACK of EFL pre-service teachers' practices in Turkey. Analysis of data collected from the TPACK scale and reflective journals showed significant growth in the participants' TPACK scores and improvement in TPACK application in EFL classrooms considering learning goals. Kwangsawad (2016) also analyzed self-reports, lesson plans, and observation data to explore EFL pre-service teachers' TPACK application in Thailand. Results showed a high level of awareness for all components. Likewise, Rubadeau (2016) examined EFL teachers' practices and perceptions of TPACK in a South Korean university by collecting qualitative data from interviews, documents, reflections, and field notes. It was found that teachers showed a high awareness level of TPACK.

Moreover, Tseng et al. (2019) explored the implementation of TPACK of six pre-service EFL teachers through design thinking. The researchers also investigated the contextual barriers that influenced participants' web-conferencing teaching. Analysis of post-teaching discussions and interviews showed an awareness of PCK compared to TCK. Besides technical problems, teachers' concerns about students' background knowledge and weak attention were significant in participants' web-conferencing teaching. Bostancıoğlu and Handley (2018) conducted TPACK for the EFL teachers' packages. Findings highlighted the necessity of integrating all domains of TPACK instead of introducing them separately.

In the Middle East, Alnajjar and Al-Jamal (2019) examined EFL teachers' level of TPACK in teaching listening and speaking in Jordan. Findings revealed inadequate levels of TK, PK, and TPACK. Alghamdi (2017) explored the TPACK knowledge of EFL male teachers in Saudi Arabia and their attitudes towards using technology in classrooms. The participants completed an online survey and went through semi-structured interviews. Results indicated that participants had adequate knowledge of implementing ICT in EFL classrooms and demonstrated positive attitudes towards the TPACK model. Similarly, Alharbi (2020) found that Saudi EFL teachers demonstrated high TPACK knowledge. Raygan and Moradkhani (2020) explored Iranian EFL teachers' TPACK, school environment, attitudes towards TPACK, and technology integration. Results showed significant associations between teachers' TPACK, their attitudes, technology integration, and the school environment.

TPACK and Teachers' Perception

Loi (2021) explored EFL teachers' perceptions in Vietnam and found that although participants had a high level of computer and technology knowledge and pedagogical content knowledge, they perceived their TPACK ability above average. Shi and Jiang (2022) investigated EFL teachers' perceptions and self-evaluation of TPACK and the factors that affect TPACK use. Using the WeChat app, the data were collected via an online TPACK survey and follow-up interviews. The quantitative results revealed teachers' strong beliefs in the value of PK, CK and PCK and their positive beliefs about technological applications in EFL instruction. However, the qualitative results of the self-evaluation of TPACK showed higher confidence levels in CK, PK, and PCK domains than in technology domains. Besides, they identified four important factors that affect using technology: 1) contextual factors, 2) knowledge of students, 3) demographic background, and 4) accessibility of quality training. Furthermore, Kusuma (2022) investigated the impact of a TPACK-related program on EFL

pre-service teachers' understanding and application of the flipped model. Data were collected from semi-structured interviews. The findings showed that the TPACK-related program improved participants' comprehension of flipped classrooms and properly integrated technology.

Similarly, Turgut (2017) investigated the perceptions of Turkish EFL pre-service and in-service teachers of TPACK in four-year-long teacher preparation programs. Results showed that participants at all levels reported that practicum and school visits were ineffective in helping them use technology in EFL lessons. Drajati et al. (2018) explored pre-service and in-service teachers' perception and application of TPACK literacy (Pedagogical Content Knowledge for Multimodal Literacy, Technological Pedagogical Knowledge, 21st Century Learning, and Knowledge about Digital Media Tools). Significant improvements were found in participants' professional development.

In the Egyptian context, Alsayed et al. (2022) examined Egyptian EFL teachers' perceived competencies of TPACK in private schools. Quantitative results showed a significant improvement in teachers' perception of their skills and knowledge regarding TPCK, whereas they were unconfident about their CK, PK, and TK levels. Kharboush (2021) investigated Egyptian EFL pre-service and in-service teachers' practices and perceptions of ICT incorporation in EFL classrooms. The findings of a questionnaire revealed that pre-service teachers surpassed in-service teachers in TK and TCK, while in-service teachers significantly outperformed their peers in PK, CK, TPK and PCK. No significant difference was found between the groups in TPCK. After attending an orientation about integrating the TPACK framework in EFL classrooms, participants were observed while teaching to track TPACK practices. Results showed that instructional practices have improved as participants' understanding of TPACK has increased.

Challenges of Integrating TPACK

TPACK was criticized for the "fuzzy boundaries" between its components and the interaction among these components (Kimmons, 2015). Schmid et al. (2020) argue that "According to the transformative perspective, TPCK cannot simply be accounted for by summing all other TPACK components, but rather it is a distinct form of knowledge which transforms beyond the components at its base" (p.3). Hence, some components like TPK, TCK, and PCK will be more effective than others. To investigate this assumption, few researchers conducted structural equation mode (Celik, et al., 2014; Dong, et al., 2015; Pamuk, et al., 2015), but the findings were inconclusive.

Furthermore, integrating TPACK into courses is challenging. For example, Cacayan (2018) found that teachers encountered challenges in implementing TPACK, such as inadequate knowledge of integrating technology and computer applications, inappropriate communication between teachers and students, weak time management skills, and students' insufficient technological skills. Likewise, Topan et al. (2020) reported that teachers faced many barriers, including computer literacy, technical problems, time limitations, and teachers' inadequate skills in designing tasks based on TPACK. Similarly, Syamdianita and Cahyono (2021) point out that EFL pre-service teachers had problems with TPACK models, such as insufficient knowledge of computer skills, low level of content knowledge, and insufficient media accessibility. Furthermore, Liu et al. (2014) explored the TPACK competence of EFL teachers and its effect on teachers' professional development. The researchers pinpointed the challenges of developing the TPACK of EFL teachers, including the difficulty of integrating technology into teachers' knowledge systems.

With the growing body of literature that tackled TPACK integration in classrooms, researchers have investigated the influence of the TPACK model on pre-service teachers' practices and perceptions by collecting data from surveys, lesson plans, observation, peer-coaching and micro-teaching, and content analysis of discussions and reflections. The findings were generally effective and supportive of the role of TPACK in improving pre-service teachers' skills and perception in the EFL contexts. Few studies have explored the adequacy of the model in the Egyptian EFL context, with a main concern on measuring in-service EFL teachers' perceptions or practices. One study has compared pre-service teachers' perceptions of in-service teachers (Kharboush, 2021). Therefore, the present study seeks to fill this research gap.

Methodology

The Aim of the Study

The current study aimed to investigate the effect of a TPACK-based course on pre-service teachers' perception, knowledge, and implementation of TPACK in EFL classrooms. To achieve this aim, the researchers sought to answer the following questions:

1- What is the efficacy of a TPACK-based course on pre-service EFL teachers' perceived importance of TPACK?
2- What is the efficacy of a TPACK-based course on pre-service EFL teachers' knowledge of TPACK?
3- What is the efficacy of a TPACK-based course on pre-service EFL teachers' implementation of TPACK?

Participants and Context

The study was situated in the Faculty of Education, New Valley University in Egypt, where senior pre-service teachers majoring in English enrolled in the Methods of Teaching English II course, first semester in the academic year 2021/2022. As for pre-service teachers' pedagogical background, the students previously studied ELT method I in the third year and micro-teaching in the second year of college. For their technological knowledge, they have taken a general computer course in the first year and a general educational technology course in the third year. Students had no specialized courses in teaching English using technology in this faculty.

Additionally, the researchers noticed that many supervisors, who mentored pre-service teachers in the teaching practicum in four schools in the New Valley, reported that pre-service EFL teachers struggle to integrate technology in their classrooms. The researchers observed some classes and conducted interviews with five supervisors. It was found that although pre-service teachers had pedagogical knowledge, their utilization of technology in their lessons is still in its infancy.

Hence, the researchers conducted a needs assessment to determine the existing pedagogical, technological, and content knowledge of EFL pre-service teachers in the Faculty of Education at New Valley University to identify their needs. The researchers created a checklist with TPACK-related skills and validated it by experts in TEFL. The researchers also created a 50-item TPACK test in light of the TPACK checklist. They administered the test and Bostancıoğlu and Handley's (2020) TPACK survey on the senior EFL students in the Faculty to assess the existing knowledge and perception. Findings showed that while students lacked sufficient knowledge in four domains (PCK, TCK, TPK, and TPCK), their level was satisfactory in three domains (CK, TK, and PK). The researchers attributed this result to the

courses related to pedagogies and instructional technologies that students studied throughout the previous college years. However, students lacked the knowledge of integrating technology into content and pedagogy.

The study sample comprised (N=30) senior pre-service teachers who did the needs assessment. The average age of the participants was (22.7), of which 4 were males and 26 were females. The course was taught for four face-to-face hours per week (a two-hour lecture and a two-hour micro-teaching session) and a weekly sixty-minute online session via Microsoft Teams. In the micro-teaching session, participants worked in a computer laboratory to facilitate their practical integration of the technological tools into their lessons.

Design and Procedure

The current study used a mixed methods design wherein researchers gathered and analyzed both qualitative and quantitative data over 10 weeks from multiple sources: 1) a TPACK questionnaire, 2) a TPACK test, 3) participants' lesson plans, 4) observations and field notes; and 4) semi-structured interviews. In week one of the study, the researchers conducted the pretest and TPACK questionnaire. Lesson plans were collected in weeks five and eight. In weeks six and nine, participants were observed and interviewed. The researchers conducted the post-test and TPACK questionnaire in week ten. Before conducting the study and administering the study instruments, participants were informed about the study aims and it was confirmed that the data collected would be used anonymously for research purposes only.

Data Collection and Procedures

EFL-TPACK Questionnaire

In light of the needs assessment results, the researchers adapted the EFL-TPACK questionnaire of Bostancıoğlu and Handley (2018). Only four domains were included in the current study: PCK, TCK, TPK, and TPCK. The adapted questionnaire comprised 16 items of a 5-Likert scale ranging from 1= I am not confident at all, 2= I am not confident, 3= I need to make an effort in this skill, 4= I am confident/proficient, and 5=I am very confident/proficient. The questionnaire was created on Google Form and the link was sent to students via a WhatsApp group.

To ensure the validity of the questionnaire, the researchers first submitted it to a jury to judge its face validity. Further, the Pearson correlation coefficients were calculated between each domain's score and the questionnaire's total scores. Results showed that the TPK domain has the highest value (.82), followed by TCK (0.80), TPCK (0.76), and finally, PCK (0.68). Thus, the four parts have a reasonable and significant correlation at the 0.01 level. This result confirms the questionnaire's internal consistency with its four domains. Finally, the reliability for all items was also high, as indicated by Cronbach's Alpha (0.86).

TPACK Test

The researchers created a test that contains 36 multiple-choice items and covers the four selected domains of TPACK. The number of items in each domain was determined based on the relative weight of the topics taught. The final number of items was specified as follows:

PCK: (10 items: questions 1-10)
TCK: (9 items: 11-19)
TPK: (8 items: 20-28)
TPACK: (8 items: 29-36)

The test was piloted to another group of senior students in the Faculty of Education at another university to check reliability. To examine the validity of the test, the researcher sent it to four jurors and necessary revisions were made. The estimated time to take the test was 30 minutes. Besides, the Alpha Cronbach's level (0.81) indicates a high reliability of the test.

Lesson Plans

Participants were provided with a lesson plan template to facilitate lesson preparation. The lesson template includes data about class level, size, duration, activity interaction type, resources and materials, the technology used, procedures, and evaluation. The researchers adapted the TPACK-Based Technology Integration Assessment Rubric (Harris et al., 2010) to evaluate lesson plans. The rubric includes four criteria that measure the four domains of TPACK. Each domain is measured against four levels: the highest grade is 4, the lowest is 1, and the total grade is 12. An expert coder assisted the researcher and analyzed the lesson plans. The inter-coder reliability was high (Cohen's kappa = 0.845).

Observations

In total, sixty lesson plans were observed and video recorded (via mobile phones) to analyze participants' TPACK performance and compare first and second observations. The lessons were observed in micro-teaching sessions and teaching practicum at schools. Students were confirmed that these videos are anonymously used to evaluate their teaching and their consent was granted. The researchers designed a rubric to assess TPACK application/performance to evaluate the integration of TPACK's four domains into teaching. Each domain contains three skills, except for TPCK, which has four skills. Each skill is measured against four performance levels, whereas the highest grade for each skill is 4 and the lowest is 1. The total grade for the three first sections is 12 each, whereas the total for the fourth section is 16.

To ensure the reliability of lesson observation scores, the researchers divided scores by two different raters (interrater reliability was .89). Researchers defined the performance levels for each item in the rubric and consulted three experts to determine the scope validity of the developed rubric and revised it based on their comments.

Semi-Structured Interviews

Semi-structured interviews were conducted with eight participants to triangulate data gathered from other sources. The researchers adapted four interview questions from Harris and Hofer (2011) to cover the four domains of TPACK. The researchers also prepared follow-up questions to understand participants' responses deeply. Data collected from interviews were transcribed verbatim to facilitate coding into four main units of analysis. Participants' responses were tabulated and coded to interpret the qualitative data from interviews using Microsoft Excel. The researchers conducted the interviews via Zoom, which lasted about fifteen minutes.

TPACK-Based Course

The researchers used the ADDIE Instructional Design model as a framework to create the TPACK-based course. ADDIE involves Analyzing, Designing, Developing, Implementing, and Evaluating. After analyzing the student's needs, the researchers designed the course content, selected the strategies, chose a course progression, specified the time frame, and identified the assessment tools in light of the course goals and learning outcomes. In the development stage, researchers created the modules and put the elements into action by drafting the course then designing and evaluating the output. During the implementation phase, the course was uploaded to Google Classroom, and participants were added to ensure they could access the materials. Finally, the course was evaluated by three EFL experts. The course comprised four Modules with hands-on tasks and assignments. Each module was taught for two weeks, as represented in Table 2.

Weeks	Modules description	Assessment Tasks
2 & 3	**Pedagogical Content Knowledge (PCK)** demonstrates pedagogical strategies and approaches to present knowledge about language skills. This module involved topics related to identifying different assessment types and tasks, planning lessons by choosing and sequencing activities appropriate to learners' language skills, choosing different assessment tasks (appropriate to language focus, aims, and learners), and using varied feedback techniques (appropriate to stage aim and language focus.	An Online quiz on Quizziz. Creating a lesson plan to integrate PPP & TBL approaches in micro-teaching sessions.
3 & 4	**Technological Content Knowledge (TCK)** incorporates topics of English using emerging technological tools to deliver content to students and encourage engagement with content. This module included methods to choose technological tools to develop language skills (e.g., smartboard, podcast, Quizlet, Kahoot, Quizzes, hot potatoes, Google Forms, etc.). It also comprised topics about ways to use technological tools/applications and Learning Management Systems to present and review language lessons.	An online quiz on Google Forms. Using a checklist to analyze lesson plans to identify the most appropriate technological tools.
5 & 6	**Technological Pedagogical Knowledge (TPK)** demonstrates knowledge of technological tools to facilitate the use of pedagogical methods. This module covered topics such as utilizing web 2.0 tools to engage students in active learning (e.g., Google Docs and slides), support learning outcomes (e.g., using Quizlet, Kahoot, Quizzes, hot potatoes, google Forms, etc.), assess learning outcomes (google Forms and gamification) and manage the learning environment while using technology in the classroom.	Design activities using Quizziz, Quizlet, or Google Forms.
7 & 8	**Technological Pedagogical Content Knowledge (TPCK)** indicates the integration of technologies, content, and pedagogies to teach content and culture and facilitate communication. This module tackled topics about facilitating cultural understanding by using technology to engage students with the target culture and develop cultural awareness. The module also includes topics related to strategies to provide students with a range of technologies to pursue their language learning and participate in digital learning communities to explore creative applications of technology to improve student language learning and use technology effectively to communicate relevant information to students and peers.	Creating lesson plans, analyzing a WebQuest, & Microteaching demos.

Table 2. TPACK-based EFL course framework

Findings

This section presents the analyses of data obtained from the test and the questionnaire, followed by the analysis of the qualitative data collected from lesson plans, observations, and interviews. SPSS V.23 was utilized to analyze quantitative data. This section is discussed in light of the research questions.

First Research Question

The first research question addressed the impact of the TPACK-based course on pre-service teachers' perception of the importance of TPACK. Paired sample t-tests were used to answer this question, measuring the mean difference between the pretest and posttest mean scores. The effect size of the intervention or the magnitude of the difference between the two variables was identified by Cohen's d. The results are presented in Table 3.

Domains	Test	Mean	SD	T	df	Sig. (2-tailed)	Cohen's d
PCK	Pretest	12.60	3.147	7.558	29	.000	1.38
	Post-test	14.63	2.723				
TCK	Pretest	11.50	2.723	8.233	29	.000	1.5
	Post-test	13.90	2.286				
TPK	Pretest	11.13	2.849	6.130	29	.000	1.24
	Post-test	13.80	2.325				
TPCK	Pretest	10.80	2.809	3.593	29	.001	0.66
	Post-test	12.73	2.559				
Total	Pretest	46.03	7.701	10.004	29	.001	1.8
	Post-test	55.06	7.919				

Table 3. Paired-sample t-test of the TPACK Questionnaire

Table 3 shows a statistically significant mean difference (9.03) in the total questionnaire means between the first administration (M = 46.03) and the second administration (M =55.06) in favor of the second (t (29) = 10.004, $p < .001$), with a large effect size (d = 1.8). The results also revealed that there was a significant mean difference (2.033) in the PCK domain between the first administration (M=12.60) and second administration (M=14.63) in favor of the second (t (29) = 7.558, p < .001), with a large effect

size (d = 1.38). This result indicates that the participants' PCK domain was improved after the intervention.

As for the TCK domain, there was a significant mean difference (2.40) in the TCK domain between the first (M=11.50) and second administration (M=13.90) of the questionnaire in favor of the second (t (29) = 8.233, p < .001), with a large effect size (d = 1.5). Concerning the TPK mean scores, they increased from the first (M = 11.13) to the second questionnaire administration (M = 13.80) with a mean difference (2.967). This mean difference is statistically significant in favor of the second application (t (29) = 6.130 p < .001) with a large effect size (d = 1.24). Similarly, the mean scores of the TPCK use increased from (M = 10.80) to (M = 12.73) from the first and second questionnaire administrations with a mean difference (1.933). There was a statistically significant difference in favor of the second (t (29) = 3.593, p < .001). Therefore, participants made significant gains in the four domains of the TPACK questionnaire after the intervention.

Second Research Question

The second research question explored the effect of the TPACK-based course on participants' knowledge of TPACK before and after the study. A paired t-test was conducted to determine the significance of the mean difference in the overall TPACK test scores from the pretest to the post-test. Table 4 displays the results.

Domains	Test	Mean	SD	T	df	Sig. (2-tailed)	Cohen's d
PCK	Pretest	5.67	1.988	6.738	29	.001	1.2
	Post-test	7.10	1.094				
TCK	Pretest	5.07	1.837	4.670	29	.001	.85
	Post-test	6.80	1.690				
TPK	Pretest	3.27	1.507	6.965	29	.001	1.27
	Post-test	5.47	2.129				
TPCK	Pretest	4.80	1.972	7.37	29	.001	1.1
	Post-test	6.73	1.143				
Total	Pretest	18.80	5.498	9.35	29	.001	1.7
	Post-test	26.10	5.616				

Table 4. Paired-sample t-test of TPACK test

It is clear from Table 4 that there was a statistically significant increase by (7.3) of the total test means between the pretest (M = 18.80) and the post-test (M = 26.10) in favor of the post-test (t (29) = 9.35, p < .001), with a large effect size (d = 1.7). The results also revealed a significant mean difference (1.433) in the PCK domain between the pretest (M=5.67) and the post-test (M=7.10) in favor of the post-test (t (29) = 6.738, p < .001), with a large effect size

(d = 1.2). Additionally, there was a significant mean difference of (1.73) in the TCK domain between the pretest (M=5.07) and the post-test (M=6.80) in favor of the post-test (t (29) = 4.670, p < .001), with a large effect size (d = 0.85).

Concerning the TPK mean scores, there was a growth from the pretest (M = 3.27) to the post-test (M = 5.47) with a mean difference of 2.20, which was a statistically significant difference in favor of the post-test (t (29) = 6.965, p < .001) with a large effect size (d = 1.27). Similarly, the mean scores of the TPCK use increased from the pretest (M = 4.80) to the post-test (M = 6.73) with a mean difference of (1.933). There was a statistically significant difference in favor of the post-test (t (29) = 7.37, p < .001) with a medium effect size (d = 1.1). Hence, participants' overall level significantly improved in the four domains of the TPACK test after the intervention.

The Third Research Question

The third research question explored the efficacy of the TPACK-based course on pre-service teachers' integration of the four domains of TPACK in their teaching practices. Therefore, an analysis of data collected from lesson plans, interviews, and observations was presented. Table 5 presents the paired-sample t-test results of the lesson plans.

Domains	Test	Mean	SD	T	df	Sig. (2-tailed)
PCK	Pretest	2.60	.498	5.037	29	.001
	Post-test	3.067	.454			
TCK	Pretest	2.63	.490	4.397	29	.001
	Post-test	3.03	.490			
TPK	Pretest	2.62	.498	4.474	29	.001
	Post-test	3.069	.450			
TPCK	Pretest	2.170	.379	4.176	29	.001
	Post-test	2.603	.498			

Table 5. Paired-sample t-test of TPACK lesson plans

Table 5 shows a statistically significant mean difference (M=.467) in the PCK domain between the first lesson plan (M=2.60) and the second one (M=3.067) in favor of the second (t (29) = 5.037, *p*< .001). The results also revealed that there was a significant mean difference (0.467) in the TCK domain between the first lesson plan (M=2.63) and the second (M=3.03) in favor of the second (t (29) = 4.397, *p*< .001). Moreover, there was an improvement in the TPK domain between the first lesson plan (M=2.62) and the second (M=3.069) in favor of the second (t ((29) = 4.474, *p*< .001), with a mean difference (M=.467). As for the TPCK domain, there was a meaningful difference (M=.433) between the first lesson plan (2.170) and the second (M= 2.603) in favour of the second (t (29)=4.176, *p*< .001). Therefore, the results seem to reveal that pre-service teachers' TPACK integration in lesson plans has improved on the TCK, TPK, PCK, and TPCK domains after implementing the TPACK course.

Additionally, the analysis of the observed lessons revealed that participants' practices significantly improved in overall score and the four TPCK domains from the first observation to the second (see Table 6).

Domains	Test	Mean	SD	T	df	Sig. (2-tailed)
PCK						
	Pretest	7.64	2.046	10.428	29	.001
	Post-test	8.68	1.285			
TCK	Pretest	6.40	2.191	4.397	29	.001
	Post-test	6.80	1.864			
TPK	Pretest	6.403	2.044	4.419	29	.001
	Post-test	7.270	1.721			
TPCK				4.097	29	.001
	Pretest	6.603	3.645			
	Post-test	6.970	3.347			

Table 6. Paired-sample t-test of TPACK observation

Table 6 displays that the PCK domain had statistically significant mean differences (M= 1.02) between the first (M= 7.64) and second observations (M= 8.68) in favor of the second (t(29) = 10.428 $p< .001$). Similarly, the TCK domain had statistically significant mean differences (M= 0.400) between the first (M= 6.40) and second observations (M= 6.80) in favor of the second (t (29) =4.419, $p< .001$). There was also a statistically significant mean difference (M= 0.87) in the TPK between the first observation (M= 6.403) and the second observation (M= 7.270) in favor of the second (t (29) =.4.419, $p< .001$). Finally, the TPCK domain also showed a significant mean difference (M= 0 .367) and there was a significant improvement between the first observation (M= 6.603) and the second observation (M= 6.970) in favor of the second observation (t (29) = 4.097, p <.001). Hence, this result shows that the participants appeared to have achieved significant growth in TPK, PCK, TCK, and TPCK domains.

To compare the results obtained from the lesson plans and the observation, Figure 2 summarizes the results of the TPACK scores delineated by the participants' lesson plans (L) and the actual integration of TPACK competencies in teaching (O).

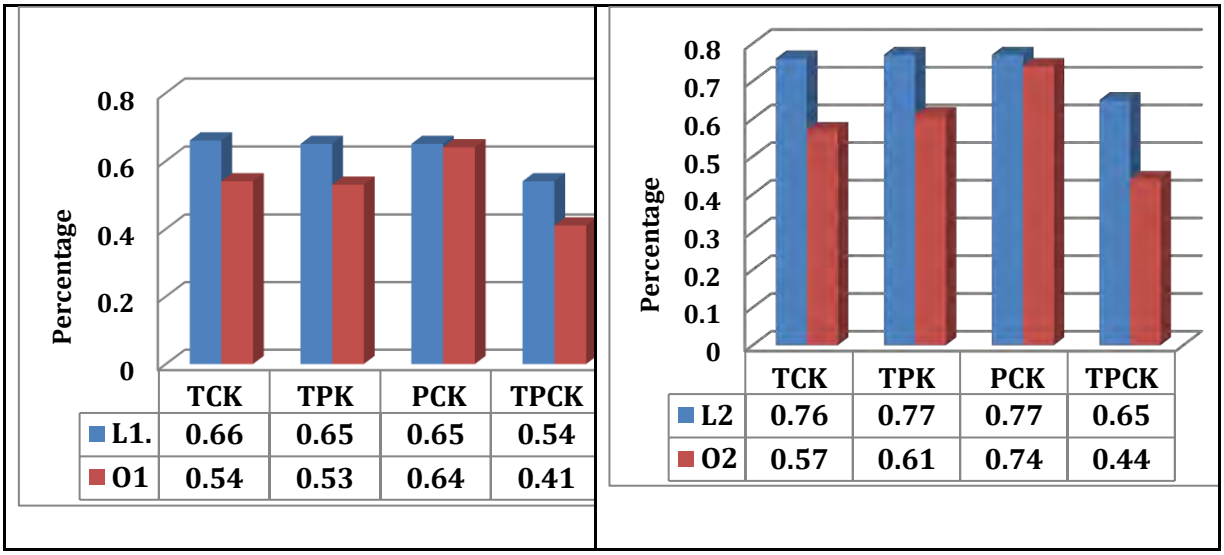

Figure 2. Comparing lesson plans to Lesson observations in times 1 and 2

As shown in Figure 2, the recorded observation scores were lower than those recorded in the lesson plans. For all four dimensions, the scores for lesson plans surpassed that of the observed actual practices except for the PCK domain, which was relatively close in times 1 and 2. Moreover, it is noticed that the TPCK domain has gained the lowest mean at time 1 (0.54 and 0.41) and time 2, respectively (0.65. and 0.44).

Additionally, the researchers conducted a content analysis for the lesson plans, interviews, and observations to identify participants' integration of TPACK in their lessons. As for the lesson plans, four themes were identified in light of the four domains of TPACK: TCK, TPK, PCK, and TPCK.

As for the results of the qualitative results, Table 7 displays the most important findings for each domain. Concerning TCK, analysis of the lesson plans revealed that most pre-service teachers used technology in a way that strongly aligned with the lesson objectives. The majority prepared lessons to teach grammar (76%), while only (10%) tackled pronunciation. Kahoot and Quizlet were the most used websites. Observation results showed that participants tended to utilize multimedia tools to introduce new vocabulary. However, few participants (27%) used technology that partially aligned with the lesson objectives. Only two lesson plans did not use technology aligned with the lesson objectives. When responding to the interview questions about the adequacy of the technological tools and their effect on the content, most interviewees confirmed that using a checklist provided by the researchers during the TPACK-based course helped them decide which tool/ resources to fit the content. However, some interviewees stated that the facilities available in the classroom limited their choices of the appropriate technologies.

Concerning integrating technology to support instructional strategies used to teach content (TPK), 31% of the lesson plans clearly referred to the instructional methods used. Additionally, nearly half of the pre-service teachers appropriately selected technology that supported the teaching methods used in the lessons. However, 13% of the lesson plans minimally reinforced the instructional strategies, and 6% of the lesson plans lacked a connection between the technology used and the pedagogy. Furthermore, observation results regarding TPK showed that the majority of the participants used online games on the Smart Board. Participants also used Google Forms to provide formative assessment. Observation results also showed that 20% of the participants used PowerPoint to enhance cooperative learning. In response to the interview questions about the selection of technology and its relation to the teaching method, interviewees asserted that they considered the methods they

studied in the course and checked which technological tool would best achieve the lesson objective.

Domain	Instrument	Results	Data Samples
TCK	**Lesson plan**	76% tackled grammatical structures, 67% addressed vocabulary, 47% targeted reading, 30% emphasized listening, 27% focused on vocabulary and speaking, and 10% discussed pronunciation.	Two participants (P1 & P11) prepared a lesson about "Robots" and aimed at teaching vocabulary related to this topic. Two participants (P3 & P18) used Kahoot and created a set of vocabulary on Quizlet to help students study the words and test their comprehension.
	Observation	80% of the participants used videos (songs and short stories) and pictures to present new vocabulary and grammar.	Participant (P12) used images to show the difference between modal verbs. Participant (P8) utilized a video about 'if' conditionals and asked students to write down the three conditions. A third participant (P7) used a song to show action verbs.
		27% used technology that partially aligned with the lesson objectives.	Participant (P28) planned to use some features of the smart board to present "the passive" without describing which features would encourage students' interaction.
	Interviews	"How did the technological tools and resources that you used 'fit' the content of the unit?"	Interviewee (P6) commented: "Using different multimedia elements attracts students more than just showing pictures or images. So, I must compare different resources and choose the most friendly-user and attractive to teach the content".
		"How, if at all, did these decisions change the content (e.g., adding or subtracting unit subtopics based on available resources)?"	Interviewee (4) said: "Answering questions in the checklist directed me to which tool to use. I had to teach the pronunciation of some new words. I sent the list of words to students on WhatsApp to look those words up and check the pronunciation before coming to the class to save time and ensure accuracy."
TPK	**Lesson plan**	31% referred to the instructional methods, 49% selected technology that supports the teaching methods, 13% reflected the instructional strategies, and 6% missed the connection.	Five participants (P2, P5, P6, P18, & P30) included flipped learning model and game-based learning in their lessons.
	Observation	73% used online games on the Smart Board and Google Forms, and 20% used PowerPoint.	Three participants (P6, P7, & P16) used Word Wheel games to introduce lead-in activities or revise grammar or vocabulary. Participant (P21) created Jeopardy on PowerPoint to revise grammar, reading, and vocabulary.
	Interviews	"How did you decide which tools to use to teach the unit content? How did these decisions change your teaching (e.g., classroom management, assessment of student learning, or ways in which you interacted with the students)?"	Interviewee (P3) said: "I usually start with the teaching methods I know from the course and check the content to see which one will achieve the objectives. I ended up choosing the technology that fits both the content and the method". Interviewee (P8) commented: "I struggle to balance the best technology and the perfect

			teaching method. I also have a problem managing time while using technology".
PCK	**Lesson plan**	26% of the pedagogical methods were exemplary, 47% chose appropriate strategies that achieved objectives, and 24% marginally described the methods.	Two participants (P3 & P13) successfully used task-based learning to teach speaking, vocabulary, and grammar.
	Observation	48% chose and implemented methods successfully. 32% did not comply with the techniques of the chosen method.	Task-based learning was the most used approach in teaching listening, speaking, writing, and grammar. Two participants (P12 & P27) stated using flipped learning and did not implement the approach correctly. They sent links to students and assigned them reading, but in the actual class, they went through the reading and taught the grammar and vocabulary without building on the out-of-class part.
	Interviews	"How did you decide how to teach the content that this unit addresses (e.g., scope, depth, or nature of the content)?"	Interviewee (P2) said, "I usually check the objectives and the target vocab or grammar related to the lesson to make sure that the method I choose is effective with students."
TPCK	**Lesson plan**	49% included technological tools appropriate for the content and teaching methods, 32% used appropriate technology to enhance the content and instructional methods, whereas 13% marginally made this link in their lesson plans by either supporting the pedagogy or the content within the same lesson, and 6% failed to connect technology with pedagogy and content.	The interactive Smart Board, Kahoot, and Jeopardy were used to encourage students to do interactive exercises and play competitive games. Podcasts and digital stories were used to teach listening in three lessons. Google Forms were used to create quizzes and surveys to assess students' mastery of learned topics.
	Observation	29% integrated technology appropriately, 10% used marginally inappropriate technology tools, and 48% shared resources with students.	Three participants (P4, P15, & P30) used Smart Board to present images that were lower to the student's language level to teach the pronunciation and meaning of new words.
	Interviews	"How and why was this particular combination of content, pedagogy, and technology most appropriate for this unit?"	Interviewee (P5) said: "I managed to integrate technology, content, and pedagogy after planning and teaching two or three lessons. I figured out the best combination of technology and methods to teach a particular content. I believe it is a matter of experience."

Table 7. Summary of the qualitative data results

Regarding the PCK domain, analyses of the lesson plans showed that 26% of the pedagogical methods selected to achieve the lesson objectives were compatible with the content. 47% chose appropriate teaching strategies that achieved lesson objectives and content. Few participants marginally described the methods used to achieve the content. Observation results indicated that about half of the participants managed to choose a method and implement it successfully in class. Some participants (32%) failed to comply with the techniques of the chosen instructional methods. The majority of interviewees reported the

necessity of considering the learning needs of the students, the familiarity of students with the content, and the appropriateness of the teaching methods to the target language skill.

As for incorporating technology into content and pedagogy (TPCK), half of the participants demonstrated a strong combination of the three components in their lesson plans. Observation results showed that few participants used marginally inappropriate technology tools, while 29% of the observed pre-service teachers integrated technology appropriately to teach content and used teaching methods that effectively achieved the objectives. Half the participants were keen on sharing resources with students to enhance their learning autonomy. Most interviewees reported that they could integrate technology with content and pedagogy as making the right integration enabled them to deliver good lessons.

Discussion

The study aimed to explore pre-service teachers' perceptions, knowledge, and practices before and after studying a TPACK-based course. The researchers conducted a needs assessment and designed a course that tackled four TPACK domains: PCK, TPK, TCK, and TPCK. The present study analyzed qualitative and quantitative data to investigate the integration of TPACK into pre-service EFL teachers' lessons.

The study's findings would contribute significantly to the knowledge base and practical implications of the TPACK framework in teacher preparation programs globally and locally. TPACK framework can be used for designing teacher preparation and professional development programs and assessing teachers' knowledge of integrating technology in classrooms. The TPACK questionnaire used in the present study provides educators and researchers with a reliable tool to assess EFL teachers' self-assessed TPACK perception. The questionnaire can be validated and adapted to be used with pre-service and in-service teachers in various contexts and with different subject areas. The questionnaire can also be translated into different languages to be used worldwide.

Moreover, the TPACK knowledge test is a valuable tool to measure teachers' understanding of the TPACK domains. To triangulate the quantitative data, the study also offers qualitative tools that can be adopted by educators and researchers to authentically evaluate the instructional practices concerning integrating technology, content, and pedagogy. Additionally, the TPACK-based course, created by the researchers in the current study, would guide researchers and course designers to consider the foundation of integrating the TPACK framework when developing teacher educational programs. Therefore, pre-service preparation programs in Egypt and abroad can benefit from the current findings in designing teacher preparation and professional development programs.

The analysis of the questionnaire data revealed that participants' perceptions of the importance of the four TPACK domains significantly improved after the course. Similarly, Karchmer-Klein and Konishi (2021) found that participants positively perceived TPACK integration in teaching. This result aligns with Alshawaf's (2020) finding of the significant increase in PCK and TCK domains after the training program. Pre-service teachers in her study perceived the TPACK model favorably.

Participants in the current study showed a high perception of TCK and their ability to use appropriate technologies to support teaching content. This result is inconsistent with Redmond and Lock (2019), who found that pre-service teachers perceived the TCK domain as difficult as technology and content constrained one another. Likewise, Loi (2021) found that participants' perceptions of TK and PCK were the highest, while their perceptions of TPK, TCK, CK, and TPCK were moderate. He contributed this to the interaction between TCK and TPCK, TPK and TPCK, and TCK and TPK. Shi and Jiang (2022) also found that

most participants perceived CK, PK, and PCK domains as higher than technological-based domains, including TK, TCK, TPK, and TPACK. Valtonen et al. 's (2020) participants also showed high confidence in TPK.

Regarding pre-service teachers' knowledge of TPACK, findings showed that participants' knowledge of TCK, TPK, PCK, and TPCK improved after the TPACK-based course. This result aligned well with Aktaş and Özmen's (2020) findings that the TPACK-based course improved pre-service teachers' PCK, TK, TPK, and TPACK. They also found that the TPACK-based course helped participants develop their skills to select appropriate ICT tools and instructional methods to achieve learning outcomes. Likewise, Santos and Castro (2021) found that pre-service teachers showed a strong understanding of the components of TPACK. Similarly, Tseng et al., (2019) concluded that pre-service teachers' discussions demonstrated more familiarity with PCK than TPK.

Findings revealed that participants' TPACK integration of TPACK in their lesson plans had increased overall, especially in integrating technologies to provide assessment, select lead-in activities, and engage and stimulate students. They used different features of the Smart Board, Kahoot, Quizzes, interactive PowerPoint, multimedia songs and videos, and Google Forms. Improvement in technology-related subdomains can be attributed to the course contribution to pre-service teachers' technology integration to develop teaching and learning. This result agreed with Emara (2020), who reported that Egyptian teachers used PowerPoint, YouTube, BBC, Ted Talks, Kahoot, and Voice of America to integrate technology into their teaching.

Findings of observation revealed that although participants in the current study improved their knowledge of the four TPACK domains, the majority demonstrated better performance in aspects related to PCK than other TPACK domains. The researchers noted the difficulty of observing TPACK-integrated domains, which is consistent with previous studies indicated that observing pre-service teachers in the integrated domains (namely TCK, TPK, PCK, and TPCK) was more difficult than observing the basic TK, CK, and PK domains (Hubbard & Price, 2013; Lee & Kim, 2014; cited in Wang et al., 2018). This result is in accordance with the integrative perspective of TPACK, which views the TPCK component as the outcome of the integration of the other components (Schmid et al., 2020). Hence, mastery of TPCK requires high levels of TPK, TCK, PCK, TK, PK, and CK, which is critical to achieve due to the incomplete understanding of the interaction and integration of the seven components and the limited time of the study duration.

Similarly, Janssen et al. (2019) and Chai and Koh (2017) asserted that integrating TPACK into lesson plans depends on developing PCK. This domain is fundamental to incorporating ICT into teaching as it requires using authentic applications and encourages students' interaction with content. In the same vein, Boschman et al. (2017) and Koh and Chai (2016) found that participants enacted PCK more than subdomains with technologies (i.e., TPK, TCK, and TPACK).

Comparing pre-service teachers' integration of technologies in their lesson plans and observed classroom performance, the researchers found a mismatch in lessons and implementation. Classroom observations revealed that participants' competencies in integrating TPACK domains were relatively low. Regarding all the domains of integrating technology (TK, TCK, TPK, and TPACK), it was found that scores assigned to participants' lesson plans exceeded their scores on observations. The researchers attributed this to the fact that performance, unlike knowledge, was affected by field challenges and beliefs. Some factors, like instability of the internet connection or electricity, affected participants' performance in the classroom. Another possible explanation for pre-service teachers' limited use of technology could be attributed to the short time of the course. The study duration was insufficient for participants to develop TPACK knowledge into more advanced digital

competencies, focusing holistically on the quality of technology use and its relation to lesson pedagogic aims.

Further, in the teacher preparation program, as Darling-Hammond and Bransford (2005, p.3) emphasized, "We know full well that it takes many years of experience to develop sophisticated expertise." Likewise, Chai et al. (2013) and Pamuk (2011) noted that sufficient teaching experience is necessary to develop pre-service teachers' integrated TPACK knowledge domains (like PCK, TCK, and TPK). The participants in this study were stepping into the initial technology uptake stage, which may involve a learning curve that might develop if given a longer time for teaching practice.

Furthermore, content analyses of lesson plans, interviews, and observation showed that most participants' use of technology focused mainly on presenting or revising but not focusing on higher-order thinking skills. This result might be attributed to participants' tendency to use technological tools that are easy to use. Previous research has shown that student-teachers tend to attach themselves to technologies and activities that are easy to use in the classroom (Ertmer et al., 2012; Polly, et al., 2020). This result is consistent with Mouza and Karchmer-Klein (2013), who found that most pre-service teachers' lesson plans involved technologies that targeted lower-order educational goals. Few participants integrated technologies that enhanced higher-order thinking skills. Only one-third of the current study's participants managed to integrate technology appropriately in content and pedagogy. This result is also consistent with Mouza et al. (2017), who reported that participants demonstrated insufficient understanding of technology integration with content and pedagogy.

Findings also showed that participants in the present study tended to overrate their TPACK competencies compared with their actual practices, which aligned with previous research findings (Kereluik et al., 2010; So & Kim, 2009). Likewise, Karakaya (2017) found a negative correlation between the results of the self-reported surveys and the lesson plan scores, indicating that the students overestimated their TPACK competence compared to their lesson plan performance. Findings revealed that participants integrated technologies with instructional strategies to achieve curriculum goals. Karchmer-Klein and Konishi (2021) found a mismatch between teachers' perceptions of the importance of TPACK and the actual integration of technologies in class. Similarly, the findings of previous studies (Lyublinskaya & Tournaki, 2014; Ottenbreit-Leftwich et al., 2010; Sang et al., 2010) found a mismatch between pre-service teachers' actual implementation of digital technologies in classrooms and their self-perception of TPACK.

Interviewees in the present study reported some challenges in implementing technologies in classrooms. These barriers included electricity outage, limited internet connection, insufficient time to use various technologies, difficulty handling technical issues, and inadequate facilities. These challenges agree with Tseng (2019) that contextual technical problems such as sound quality negatively impact students' concertation. This result is also consistent with barriers that Valtonen et al. (2020) reported, indicating insufficient time to apply activities and uncertainty in implementing the assessment. Participants in this study also reported problems regarding selecting the appropriate technology or combining content, pedagogy, and technology. Likewise, Valtonen et al.'s (2020) participants reported challenges related to TPK, including difficulty implementing specific technologies like the Smart Boards and supporting students using ICT during lessons. Challenges pertaining to TCK involved meeting the diverse needs of students in EFL classes, boosting their motivation while using technologies, and reducing misbehavior while using technologies.

Conclusion

The current study has potential theoretical and practical significance. Theoretically, the TPACK model provides a framework to significantly assess teachers' skills and knowledge in using educational technology. Practically, the study will provide implications for decision-makers and educators to design teacher preparation and professional development programs for teachers to qualify them to integrate technology inside classrooms. Hence, teacher preparation programs must focus on TCK, TPK, PCK, and TPCK to ensure the direct transfer of knowledge from one domain to another. Integrating content knowledge and its interaction with technology and pedagogy in pre-service teachers' programs is pivotal. Moreover, TPACK-based teacher education programs should be provided to pre-service teachers throughout the four-program year. To effectively integrate the TPACK framework, educational technology courses, content-based courses, and teaching pedagogy courses must be provided to pre-service teachers with an emphasis on implementing knowledge in teaching practicum. With the rapid technological improvement, teaching methods and content knowledge courses must keep up-to-date with the technology-infused learning and teaching environment.

Educators and administrators can benefit from the results of the current study. First, it is highly recommended that educators raise pre-service teachers' awareness of the importance of integrating technology in EFL classes. Pre-service teachers must be aware of educational technology tools to achieve educational goals. Furthermore, collaboration in communities of practice with experienced in-service teachers could improve pre-service and novice teachers' mastery of TPACK. Curriculum developers should integrate technologies into the curriculum. Administrators should provide teachers with customized TPACK professional development courses to create TPACK-based lesson plans.

The study was conducted in one regional university in Egypt and the participants may not represent all pre-service teachers all over Egypt. Additionally, the small sample size and the data collected at a single point in time may reduce the possibility of tracking participants' progress. Therefore, future research could investigate pre-service teachers' development throughout their years in college. Hence, tracking pre-service teachers' progress and collecting longitudinal data will be possible. Measuring TPACK at national and international levels could also be interesting for researchers. Further studies could compare the TPACK level of both in-service and pre-service teachers. Moreover, the present study was limited to the instruments used to collect participant data; therefore, future studies could consider using other instruments, such as reflective journals, to understand TPACK performance better. Future studies could also assess more subdomains of TPACK and its impact on participants' teaching performance.

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