#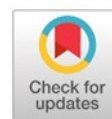 How EFL teachers perceive and self-evaluate the knowledge components in forming Technological Pedagogical Content Knowledge (TPACK)

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## ARTICLE INFO

## ABSTRACT

Technology is widely involved across the learning environment including its integration into teaching English as a foreign language (EFL); however, few studies have explored EFL teachers' perceptions of technological pedagogical content knowledge (TPACK). This study investigates how EFL teachers perceive and self-evaluate knowledge of content (CK), pedagogy (PK), and technology (TK), the interplay of these with each other (TPACK), and the underlying influential factors for TPACK construction. The data were gathered in China from an online survey ($n = 64$) comprising 35 items on the TPACK components, and self-evaluation by nine survey participants of their TPACK in follow-up interviews. WeChat, the most popular social media App in China, was utilised as the data collection tool. The survey reveals teachers' strong beliefs in the value of PK, CK and PCK and their positive beliefs about technological applications in EFL instruction. Consistent with these results, interviewees' self-evaluation of TPACK demonstrates that they felt a high level of confidence in CK, PK and PCK but relatively less confidence when technology was integrated despite commonly applying technology to instruction. Influential factors include: 1) contextual factors; 2) knowledge of students; 3) demographic background; and 4) availability of quality training. Decision-makers' financial support and policy-making, technological training in the integration of CK and/or PK, and a collaborative learning strategy are recommended.

## 1. Introduction

An increasing number of institutions throughout the world are applying technology to education, and the use of technology in language teaching and learning has also received significant attention (e.g., Banditvilai, 2016; Ekrem & Recep 2014; Hong, 2010; Liu, Liu, Yu, Li, & Wen, 2014). Starting in early 2020, the Covid-19 pandemic has been a catalyst that largely boosted the application of technology and research on teaching with the technology. The applications of technology in education involve teachers' instructional practices and knowledge of technological tools (Willermark, 2018). Therefore, language teachers need to be equipped with technological knowledge as a pedagogical tool and an essential component of their knowledge base to represent content knowledge of the target

language and enhance students' learning. They not only need to evaluate the technology in many forms but also to understand "what" the technology can do and "why", to assist their teaching (Dalal, Archambault, & Shelton, 2021; Wei & Gao, 2016). However, little is known about how (language) teachers' tech-involved instruction outcomes are related to their beliefs about the fundamental knowledge components of content, pedagogy and technology, and the interplay between these.

In China, teaching with technology is a requirement for teaching English as a foreign language (EFL) mandated in the current national College English Curriculum Requirements (CECR) issued by the Ministry of Education of the People's Republic of China in 2007. The CECR states, the new EFL teaching model "should … give play to the advantage of traditional classroom teaching while fully employing modern information technology … Changes in the teaching model by no means call for changes in teaching methods and approaches only, but, more important, consist of changes in teaching philosophy and practice …". Under this guidance, university EFL teachers are required to accept, obtain and integrate technological knowledge with their traditional classroom teaching strategies.

The term, technological pedagogical content knowledge (TPACK) (Mishra & Koehler, 2006), was proposed as an extension of pedagogical content knowledge (PCK) presented in Shulman's (1987) model, presenting the essential knowledge that teachers must possess to succeed in teaching with technology. Of Schulman's seven components of the teachers' knowledge base, the most important are: Knowledge of subject matter content (CK); pedagogy (PK - the ability to employ strategies to improve student learning such as classroom management); and PCK (the ability to use PK to deliver CK). Successful technological applications require an understanding of how technology is related to pedagogy and content (Koehler & Mishra, 2005) and the TPACK framework (Fig. 1) illustrates how teachers' appropriate combination of technologies with instructional strategies can effectively support their delivery of CK to their students. In addition to the existing components of PK, CK and PCK (Shulman, 1987), the four new knowledge areas of TK, TCK, TPK and TPACK are defined based on prior studies (Mishra & Koehler, 2006) as follows:
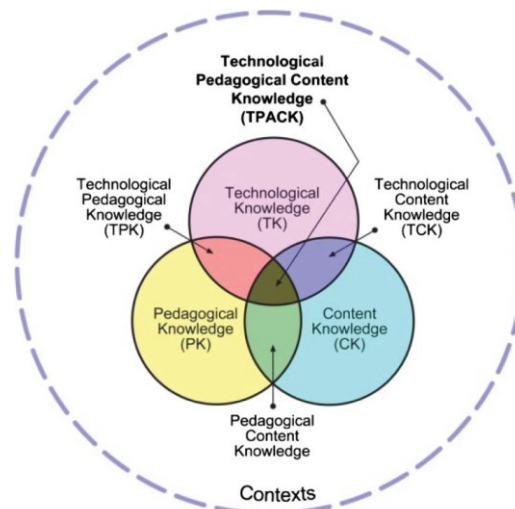


**Fig. 1.** The framework of TPACK (*source: http://tpack.org/*). Reproduced by permission of the publisher, 2012 by tpack.org

Technological Knowledge (TK): The awareness of digital tools, and how these tools can be used in learning environments;

Technological pedagogical knowledge (TPK): Teachers' understanding of technology and its application to pedagogical strategies;

Technological content knowledge (TCK): Teachers' capability to use technology to represent subject matter; and

TPACK: The integration of PCK, TPK and TCK.

While TPK and TCK are conceptualized as teachers' understanding of and capability in employing appropriate technologies to enhance pedagogical strategies and to represent CK, the complex form of TPACK is the thoughtful use of TK, representing "a class of knowledge that is central to teachers' work with technology" (Mishra & Koehler 2006, p. 1029). This is contextualized knowledge integrating TK and PK on specific CK (Archambault & Crippen, 2009); which thus emphasizes teachers' understanding of how to present CK through the effective use of technology with appropriate strategies in their contexts.

The TPACK framework provides a theoretical lens through which teachers' TPACK and capability of enhancing student learning with technology can be evaluated, and thus has drawn much research attention. While there have been increasing applications of technology in teaching practices and research on TPACK (e.g., Archambault & Crippen, 2009; Chai, Chin, Koh, & Tan, 2013; Dalal et al., 2021; Lin, Tsai, Chai, & Lee, 2013; Mishra & Koehler, 2006; Sahin, 2011; Schmidt et al., 2009; Wei & Gao, 2016), studies regarding EFL teachers' perceptions about the value of the seven TPACK components and their relationships with teachers' TPACK outcomes are rare. Most of the existing studies are quantitative surveys assessing teachers' TPACK; but few are in-depth investigations about how EFL teachers perceive and construct TPACK and the underlying influential factors. This is also true in China, even though the CECR (2007) advocates the requirements of "changes in teaching philosophy" and integration of technology into traditional instruction.

However, teachers are less likely to implement innovations when mismatches exist between the main principles underlying the curriculum and teachers' beliefs, which may become the most crucial obstacles to implementing educational innovations (Shi, Delahunty, & Gao, 2019). "What teachers know, believe and think" is defined as 'teacher cognition' (Borg 2003, p.81), which is also referred to using a wide range of concepts including knowledge, attitude, beliefs, conceptions, perceptions and understanding (e.g., Baker, 2014; Borg, 2003). What teachers believe "shapes what teachers do" (Borg 2003, p. 95). The application of technology in teaching practice is also largely influenced by teachers' beliefs about its value (De Paepe, Zhu, & Depryck, 2018; Ertmer, Ottenbreit-Leftwich, Sadik, Sendurur, & Sendurur, 2012; Lehtinen, Nieminen, & Viiri, 2016). Accordingly, EFL teachers' beliefs in TPACK and its components for enhancing EFL teaching and learning strongly influence their motivation for learning and using technology as well as the development and performance of their TPACK.

This study explores Chinese EFL teachers' beliefs regarding the value of the TPACK knowledge components and their self-evaluation of their performance in these knowledge areas. After a review of relevant literature, it describes qualitative survey findings on teachers' perceptions, before discussing more in-depth information about EFL teachers' beliefs and their self-evaluation of their TPACK outcomes as presented in interviews. The self-evaluation results are compared, then viewed alongside teachers' perceptions of the value of TPACK components. Underlying factors affecting EFL teachers' TPACK outcomes are also discussed, to provide professional development suggestions for achieving tech-enhanced EFL instruction.

Researchers have applied the TPACK framework to develop survey instruments to evaluate the TPACK profiles of both pre- and in- service teachers across disciplines. Sahin's (2011) survey of pre-service teachers studying English language education in Turkish demonstrates that the survey instrument is a valid and reliable tool for examining teachers' TPACK. The instrument included seven subscales and 47 items related to the seven essential components of the TPACK framework. Similarly, Archambault and Crippen (2009) developed a survey instrument including 24 items to examine online teachers serving in K-12 schools in the United States regardless of their disciplines. It found that teachers felt very confident about conveying the CK through various strategies which drew upon their PK. In contrast, teachers became less confident when technology was involved. The relationship of teachers' TK with their knowledge of content and pedagogy was minimal.

Schmidt and colleagues' (2009) influential evaluation instrument comprises 58 items to allow pre-service teachers majoring in early childhood education to self-assess the development and application of TPACK. This instrument was adopted in a survey (Lin et al., 2013) on pre- and in- service Singaporean science teachers. This examination revealed significant and positive correlations of teachers' synthesized knowledge (of technology, content, and pedagogy) with all other TPACK knowledge components. It also found that teachers' perceptions of TPACK are influenced by their demographic factors such as teaching experience, gender and age. Schmidt et al's instrument was also

utilized in one of the few studies on EFL teachers' TPACK in Turkey (Ekrem & Recep, 2014), revealing pre-service EFL teachers' positive beliefs in all TPACK components and identifying the impact of gender on teachers' different knowledge performances. All pre-service EFL teachers were found to have used the internet regularly, but their TK Mean score was the lowest, whereas TPK was the highest among the seven Mean scores of the TPACK factors.

Xiang and Ning's (2014) evaluation in China was adapted from both Schmidt et al.'s (2009) and Archambault and Crippen's (2009) instruments, based on their consideration of the discipline (mathematics) of their pre-service teacher participants. The Chinese preservice mathematics teachers were found to be most competent in CK but least competent in TPACK, being more familiar with traditional (non-tech-related) ways of instruction.

Schmidt et al.'s (2009) survey instrument has also had a significant impact on another study on TPACK in Singapore in which Chai et al. (2013) modified this instrument to investigate the profile of 349 primary and secondary school teachers' TPACK with the supporting evidence of teachers' pedagogical beliefs. As for the preservice mathematics teachers in Xiang and Ning's (2014) study, the participants, in-service Chinese Language teachers, rated themselves as most competent in CK but least competent in TPACK. The findings from an open-ended question further supported the teachers' self-rated profile, demonstrating that teachers' TPACK requires teachers' constructivist pedagogical beliefs more than traditional beliefs.

Another study on EFL teachers' TPACK was mixed-method research in Taiwan (Liu & Kleinsasser, 2015), focusing on the development of the TPACK of six vocational high school EFL teachers who participated in a yearlong professional development program on technology. The study demonstrates the development of these EFL teachers' TPACK and self-efficacy of technological applications in instruction. It also recognizes the importance of administration support, partnership with universities, and peer collaboration as positive influential factors that facilitated teachers' implementation of technology.

Despite the significant research attention to TPACK across the educational field, existing studies are commonly based on self-evaluation (Willermark, 2018); however, teachers, who are the key factor in the success of technological reform, have varied beliefs in and/or ways of applying technology to instruction. Meanwhile, most studies (e.g., Archambault & Crippen, 2009; Sahin, 2011; Schmidt et al., 2009) are questionnaire surveys on teachers' perceptions of TPACK (Chai et al., 2013); however, more reliable data and accurate measurements of teachers' competency can be achieved from interviews with teachers (Ekrem & Recep, 2014). Likewise, available studies focusing on teachers' perceptions of computer technology mainly look at its relationship with teachers' implementation of technology in classroom practice (Wozney, Venkatesh, & Abrami, 2006). Hence. there is a "lack of studies about the relationship between teachers' TPACK and teachers' beliefs" (Chai et al. 2013, p. 657); and even more limited is research on EFL teachers' perceptions of TPACK.

Thus, to address a gap in the literature, the present study investigated EFL teachers' perceptions of TPACK through both surveys and interviews. This is significant because 1) existing studies on TPACK are mostly questionnaire assessments; 2) there is no existing research on how teachers' beliefs regarding the value of TPACK components are related to their TPACK outcomes; and 3) the literature about EFL teachers' TPACK is limited.

Three research questions (RQ) guided the study:

1) How do EFL teachers perceive the knowledge components of content, pedagogy, and technology in teaching?
2) How do EFL teachers perceive the integration between the knowledge components of content, pedagogy, and technology in teaching?
3) What are the possible factors affecting the development of EFL teachers' TPACK?

## 2. Method

Data collection methods comprised an online survey and interview. The surveys explored how teachers value each TPACK component, from the premise that what teachers believe directly impacts what they do in teaching practice (Borg, 2003). Successful integration of technology depends on teachers' acceptance of technology as a useful tool in supporting their students' learning outcomes

(Liu et al., 2014; Wozney et al., 2006). In addition, an insight into EFL teachers' perceptions is obtained from teachers' self-evaluation statements about their TPACK performance in follow-up interviews. Emergent themes with regard to individual interviewees' knowledge of content, pedagogy and technology, and the interactions between these knowledge areas were compared to reveal possible links across the participants and the underlying factors related to their TPACK performance. Relevant suggestions are provided to motivate and support EFL teachers' professional development in TPACK and tech-enhanced EFL teaching.

## 2.1. Participants

A total of 64 EFL teachers, serving at 25 universities across China, completed the online questionnaire in December 2019. With ethics approval from the lead author's university, the second author sent an initial survey invitation and the questionnaire to her personal contacts. For snowball sampling, all teachers were encouraged to forward the questionnaire to invite their colleagues' participation. The participants' mean age was 36, and the percentages of young (less than 35), medium-aged (35 to 50), and older teachers (over 50) are 54.6%, 35.9%, and 9.5% respectively. The gender ratio of females and males is 64.06% to 35.94%. Regarding participants' university EFL teaching experience, they were considered as novice (1-5 years, 30.1%), experienced (5-15 years, 39.2%), and veteran (over 15 years, 30.7%).

In January 2020, nine survey participants also participated in a follow-up, semi-structured interview, and their demographic information is summarized in Table 1. As shown, all participants are veteran teachers with 17 to 26 years' teaching experience and were teaching EFL courses to develop students' overall English competence (College/Academic English) and for specific purposes (T2 and T6).

Table 1. Teacher Interviewees' Background

| Teacher codes | Age | Gender | Education background (M.A. in) | Years of EFL teaching | Subject of teaching |
|---|---|---|---|---|---|
| T1 | 45 | Female | Applied Linguistics | 19 | Academic English |
| T2 | 46 | Male | English | 19 | Fundamental medical English & Academic English |
| T3 | 40 | Male | Pragmatics | 17 | College English |
| T4 | 46 | Female | International Relationship | 20 | College English |
| T5 | 45 | Female | English & Literature for Applied Linguistics | 22 | College English |
| T6 | 44 | Female | English & Literature | 23 | College English & Police College English |
| T7 | 53 | Female | Applied Linguistics | 26 | Academic English |
| T8 | 48 | Female | English teaching | 24 | Academic English |
| T9 | 44 | Female | Education | 22 | College English |

## 2.2. Instrument

Tseng's (2014) instrument, which is developed based on Mishra and Koehler's (2006) TPACK framework, was adapted for both the survey and interview and used as an analytical tool to frame EFL teachers' perceptions of the knowledge component in TPACK construction. Acknowledging the value of students' views, Tseng (2014) introduced an instrument to examine EFL teachers' TPACK from students' perspectives in Taiwan. Based on the seven knowledge components in the TPACK framework, the researcher designed five items for each component to ask for students' comments on their teachers at a five-level scale. The instrument was demonstrated to be a valid and reliable tool for measuring students' perceptions of their EFL teachers' TPACK.

This instrument was chosen because teachers' experiences of using technology are different depending on the areas of teaching content (Schmidt et al., 2009). The present study shares similarities with Tseng's study in both the discipline (EFL) and the learners' first language (Chinese). Tseng's scale consists of 35 statements on EFL teachers' TPACK, including 5 items for each of the seven TPACK components (Mishra & Koehler, 2006) to ask for students' opinions of their EFL teachers' TPACK performance on a five-level scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Relevant modifications were made to the statements to meet the focus of this study on EFL teachers' perceptions instead of students' perspectives.

The survey provided an overall picture of Chinese in-service EFL teachers' views about TPACK components, responding to RQ1 and RQ2.

Semi-structured interviews collect in-depth information about teachers' perceptions and self-evaluation of TPACK performance (RQ1 and RQ2) and the underlying influential factors (RQ3). The employment of the qualitative method can explore teachers' perceptions and implementation of TPACK in depth (Archambault & Crippen, 2009). Thirteen guiding questions (see Appendix) were designed based on Tseng's (2014) instrument, covering the seven TPACK factors. All interviews were about 30-minutes long and in English by interviewees' choice, and audio-recorded with consent. The first author's transcriptions of the recordings were confirmed as an accurate account by the interviewees.

WeChat, the most popular social media App in China, was employed as the data collection tool. Prospective participants received the survey questionnaire file as a WeChat text message and could complete and submit the questionnaire on WeChat directly. Survey participants who were willing to participate in a follow-up interview were contacted and then interviewed by the first author through WeChat audio calls.

### 2.3. Data analysis

Descriptive measures were utilized in the survey to explore the degrees to which EFL teachers perceived the importance of 35 TPACK items. Due to the small number of respondents ($n = 64$), the survey findings are discussed as a supporting data source complementing the interview findings. Reported results include mean (M) scores and standard deviations (SD) of the seven TPACK components, and the top and bottom five Ms out of the 35 items. When analysing interview data, the Guest's (2012) thematic analysis method was applied. The analyses firstly focus on individual cases to find the evidence of teachers' knowledge of content, pedagogy and technology, the interactions between them, and the factors related to their TPACK performance. Then, the findings are compared across the cases. Finally, EFL teachers' beliefs regarding the value of each TPACK component (survey findings) and its relationship with veteran teachers' self-evaluation results of their TPACK outcome, and the underlying factors impacting teachers' TPACK outcomes (interview findings), are discussed.

## 3. Findings

Survey results indicate that EFL teachers considered all seven TPACK components (CK, PK, TK, PCK, TCK, TPK, and TPACK) important in their EFL teaching, but at varying levels. Different interplays between the basic knowledge components of content, pedagogy and technology were apparent.

### 3.1. All TPACK components are important but at different levels

EFL teachers' overall positive belief in the seven TPACK components can be identified from their Mean and SD scores. Fig. 2 shows that the Mean scores of all seven components are over 4.00, evidencing EFL teachers' overall positive belief in the importance of all TPACK components. The high Mean scores of TPK, TCK and TPACK also indicate that teachers' technical applications were based on their consideration of both pedagogy and content. Among these scores, the Mean scores of PK ($M$=4.6) and CK ($M$=4.53) are the top two highest and TK ($M = 4.09$) is the lowest, suggesting that PK and CK were believed to be the most important, whereas TK was the least important of all seven TPACK components. On the other hand, the SD results in Fi. 3 indicate that, while teachers were in high agreement about the role of PK ($SD$=.034) in contributing to successful EFL teaching, differences in their views about TK were significant ($SD$=.388). Teachers' attitudes towards tech-supported teaching appeared to be related to their age as evinced from the Mean scores of younger teachers ($M$=4.16), medium-aged ($M$=4.10), and older teachers ($M$=3.70). No clear evidence was found to relate these attitudes to other demographic factors such as gender or teaching experience. In the meantime, the small SD range of the other five TPACK components (from .101 to .144) indicates that teachers were generally in agreement about their functions in achieving successful EFL instruction.

Because PK and CK were much more valued than TK, it is not surprising that their interplay PCK ($M$=4.44) was considered as the third important TPACK component; by contrast, TPK ($M$=4.31) and TCK ($M$=4.23) were the two least important, following TK. Thus, teachers' relatively weak belief about the importance of TK was the key source negatively impacting their beliefs regarding the other TK-integrated TPACK factors, namely, TCK and TPK and, ultimately, TPACK.
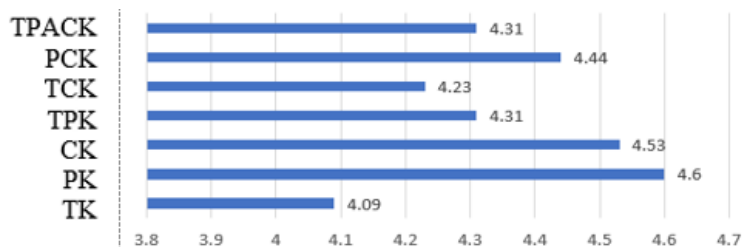


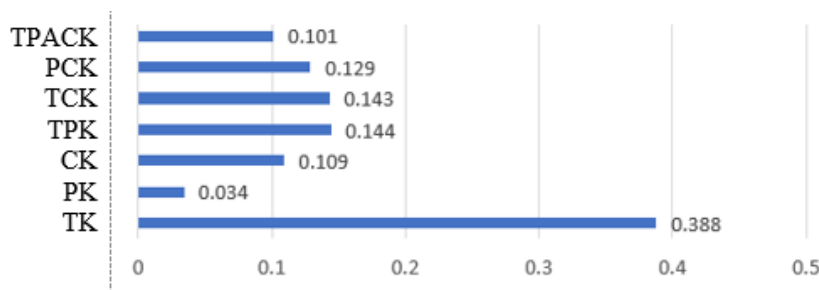**Fig. 2.** Mean of seven TPACK factors



**Fig. 3.** SD of seven TPACK factors

Table 2 and Table 3 present the five items with 'top' and 'bottom' Mean scores respectively. The top five items comprise two CK and three PK items. They include having CK of good pronunciation and sufficient grammar knowledge, and PK of understanding students' learning difficulties, being able to choose various teaching strategies with flexibility to adhere to student's needs. In other words, finding appropriate strategies (PK) to deliver comprehensible CK to students is the priority of survey respondents, which also reflects their strong beliefs in PCK.

Table 2. Top Five Items

| Items | TPACK components | N | Means | SD |
|---|---|---|---|---|
| EFL teachers should have good pronunciation. | CK | 64 | 4.66 | 0.570 |
| EFL teachers should have sufficient knowledge of English grammar. | CK | 64 | 4.64 | 0.574 |
| EFL teachers should understand students' learning difficulties. | PK | 64 | 4.63 | 0.519 |
| EFL teachers should adjust the ways he/she teaches according to student performance and feedback. | PK | 64 | 4.63 | 0.642 |
| EFL teachers should use a variety of teaching strategies in class (e.g., explanation, raising questions, and group work). | PK | 64 | 4.6 | 0.657 |

Teachers' least concerns are related to TK, TCK and TPK (Table 3). Specifically, TK of computer hardware and of software technical problems was believed to be the two items of least importance. Teachers' minimal attention to solving hardware problems aligns with Ekrem and Recep's (2014) research. Similarly, little attention was given to the application of digitalized materials to teach vocabulary or grammar (TCK), or to the use of technological strategies to enhance explanations and interactions with students (TPK).

Table 3. Bottom Five Items

| Items | TPACK components | N | Means | SD |
|---|---|---|---|---|
| EFL teachers should use digitalized teaching materials with which their students can learn vocabulary better. | TCK | 64 | 4.09 | 0.938 |
| EFL teachers should know about basic computer hardware (e.g., RAM, network cable, and projector). | TK | 64 | 4.092 | 0.921 |
| EFL teachers should use digitalized teaching materials with which their students can learn grammar better. | TCK | 64 | 4.17 | 0.951 |
| EFL teachers should use technologies to explain clearly. | TPK | 64 | 4.17 | 0.846 |
| EFL teachers should use technologies to interact more with students. | TPK | 64 | 4.19 | 0.852 |
| EFL teachers should know how to deal with technical problems related to software (e.g., installing drivers, setting up Internet connection, and sharing files in the cloud). | TK | 64 | 4.19 | 0.921 |

Interview findings provide in-depth information about EFL teachers' self-evaluation of their TPACK components and the factors affecting TPACK development. Emerged interview themes demonstrated EFL teachers' high confidence in their CK, PK and PCK, the apparent interaction of their TK with CK (TCK) and PK (TPK), and TPACK as the overall knowledge of presenting CK with TK.

### 3.2. High confidence in CK, PK and PCK

Interview participants showed strong confidence in their knowledge of content and pedagogy, and capability for employing suitable strategies to deliver comprehensible content knowledge to their students. 'Task-based' and 'student-centered' were teachers' favorite approaches. According to T7, 'student-centered' teaching is "the most important strategy", and she would "try to improve the teaching efficiency by organizing more activities". T5 and T8 often promoted students' active participation by designing lots of learning activities, such as peer discussions, group presentations and debates, to practice the new CK regardless of a large class size (50 to 100 students) situation. Both T1 and T5 explained, "Learning a language is through using it". In addition, motivation was perceived as an important vehicle that drives students' positive attitudes toward achieving successful language learning (Banditvilai, 2016). The interviewees made great efforts to achieve "fun" (T1) and "motivation" (T3, T5, and T6) in their classes. T5 asserted: "It's important to motivate students to speak, to write, to debate, to use the language…to encourage their teamwork, cooperate and communicate to their peers". In other words, in these veteran EFL teachers' PK, all pedagogical choices should be based on their knowledge of students; and motivating students' active participation and target language use is the priority. All teachers revealed a high level of confidence in making strategic choices for their students, which is inseparable from their long-term teaching experience as veteran teachers.

Teachers' pedagogical designs were often oriented toward the teaching content or topics. As stated, the teachers "design activities depending on the topic and have students involved" (T1), and arrange students "to ask each other questions related to the text content" (T9). Such interplay between PK and CK was based on teachers' knowledge of their students. Student-centered activities such as group discussions were used to motivate students' collaborative use of the target language "if the content is easy for them to understand" (T2); while traditional teacher-centered approach (T2) and translation strategies (T3) were applied when the teaching content was too challenging/complicated to encourage students' language use. The statements above reflect the teachers' strong confidence in their PK, CK and PCK, as a result of their proficiency in these knowledge components and the knowledge of students.

### 3.3. Evidenced interplay of TK with CK (TCK) and PK (TPK)

Interview results also evinced teachers' TPACK: Employment of technology as a tool (TK) to complement, convey and explain (TPK) content knowledge (TCK), and to encourage students' engagement (TPK/TPACK). The technology was an essential tool in all interviewees' teaching preparation and delivery. However, when asked about their confidence in TK, while four teachers (T2, T5, T6 and T8) described their TK as "above average" the other five lacked such confidence. All teachers' general technological applications included Word processing, PowerPoint (PPT), video

player software, social media apps, and internet search. Seven of the interviewees frequently searched online resources (e.g., the Baidu website) to enrich teaching materials, reflecting the interplay of TK with CK. For example, T4 used online resources and introduced her students to some background information when teaching about Valentine's Day. Furthermore, all teaching venues were multimedia rooms, or at least had standard audio-video equipment including Overhead Projector, screen, projection, and desktop computer (and laptop input). PPT slides (and video player software and Word documents) were mostly prepared as pedagogical tools to display (TCK) and explain the main teaching content (TPACK) and establish activities (TPK), replacing the traditional method of blackboard use (T1 and T4) and "stimulating students' interests" by showing audio and video resources (TPK) (T4).

Besides, the WeChat App was used by all teachers as an important platform for enhancing teacher-student (T-S) and student-student informal interactions outside the class. All teachers created WeChat groups for each class to send students notices, tasks and resources et cetera (TPK). The adoption of WeChat compensated for the lack of interaction in formal classes because of the situation of large-sized classes. Enhanced T-S communication can positively motivate students and influence their learning attitude (Banditvilai, 2016). The EFL teachers also benefitted from their regular use of WeChat in motivating their students (TPK).

The EFL teachers' responses regarding their use of technology reveal that, while technology was widely implemented to support their instruction, their technological applications were generally at a basic level. The interplay of TK with their PK (e.g., using technological equipment for instruction, to stimulate students' interest, and motivating students; using WeChat to enhance communications) and CK (e.g., finding online resources to enhance teaching materials) was apparent, reflecting teachers' TPACK. However, except for the use of digital equipment at the teaching venues and the limited software purchased by the schools, the manner of technological application appeared basic, but expressive and informative (Wozney et al., 2006). For example, the internet was used to find online materials, and PPT was used for displaying content. No communication tool (e.g., email, conferencing) was used except for WeChat; and no tool was for recreation (e.g., games), instruction (e.g., practice), or expansion (e.g., brainstorming).

### 3.4. Factors affecting EFL teachers' technological applications and TPACK development

The interview results suggest several factors significantly affecting EFL teachers' technological application and TPACK development.

The first is related to contextual factors. The availability of technological equipment at teaching venues directly influenced teachers' application of technology and the interplay of teachers' TK with PK and CK. T2 stated, "If we want to carry out lots of student-centered activities, we need more access than standard equipment. For example, if there are two presenters, we can show different contexts. We can switch the content on the boards". T2's employment of student-centered activities was tech-supported and was largely dependent on the available technological equipment. 'Inadequate equipment' was pointed out as a barrier preventing his application of technology to enhance his strategy (TPK). However, T7 raised an issue of data access: "I try to find something interesting online at home. We have to pay a lot if we exceed 50 MG data allowance at the university". The restriction of data usage surely limited T7's and her colleagues' technological application (TK), whether this was in the integration with PK, CK, or both.

Decision-makers can be another influential contextual source. T6 talked about technological applications as both an EFL teacher and the Head of School:

> If the current application is not useful, maybe I would search other technologies or strategies. Sometimes such application of technologies is driven by the university. We're required to have this kind of online course. It's becoming a must... some of the EFL teaching platform provided by the publishing house is rather sophisticated... but first I need to get the approval… get the financial support. If it is approved, there should be this kind of training for all the teachers in my department. (T6)

As an EFL teacher, T6 considered that technological innovation "is becoming a must" and felt the need to receive professional training in technology. Her professional concerns were about the effectiveness of technologies in assisting EFL teaching, and her judgments were about the result of interactions between her knowledge of the new technology and accumulated PCK. As the Head of

School, T6 applied for (financial) approval for a new technological application and planned to have teachers trained accordingly. Her statements demonstrate the important role of decision-makers as the driving force for enhancing tech-supported instruction and teachers' TPACK construction - the crucial factor to guarantee the effectiveness of innovation (Leithwood, Day, Sammons, Harris, & Hopkins, 2006).

Archambault and Crippen (2009) assert that the integration of technological knowledge in forming TPACK is contextualized and inseparable from the environment. It is within specific contexts that such development happens through the interaction between teachers' CK, PK and TK (Mishra & Koehler, 2006). In the present study, whether regarding the availability of technology equipment (T2), the issue of data usage (T7) at the teaching venues, or decision-makers' requirement for enhancing teaching with technology, their support for purchasing new technological tools and their offering of teacher training in new technology (T6), all demonstrated the crucial role of context in developing teachers' TPACK and achieving technological innovation.

The second influential factor is linked to teachers' knowledge of their students. T3 stated, "If students' English proficiency level is low, I use PPTs to make myself understood better. Otherwise, they can have a good discussion in class". It is clear that T3's strategical decisions were based on the integration of his TK with both his PK and knowledge of his students' English proficiency levels. Technology implementations are likely to happen when teachers, such as T3, believe that technology can be a beneficial pedagogical tool to support students' learning of CK. Similarly, teachers would apply technology if it is evaluated as helpful to foster their students' engagement (e.g., T5, T7, and T8) and their understanding of CK (e.g., T1, T2, and T9). This finding supports Ertmer et al. (2012) and Saudelli and Ciampa (2014) who argue that teachers' positive beliefs and attitudes towards technology in student learning have the biggest impact on teachers' success in technology integration practice. It also aligns with Nezvalová (2011) who asserts that the knowledge of students is more significant than PK. Even when technology is integrated into pedagogy, as demonstrated by the interviewees, teachers' knowledge of their students still has a powerful influence on any instructional decision.

Thirdly, teachers' knowledge base accumulated from their learning and teaching experience has a significant impact on EFL teachers' use of technology and TPACK construction. As discussed earlier, teachers' technological decisions were oriented by "the target of teaching" (T1, T4, and T9), according to "the tasks" (T4) or "what materials or what kind of information to convey" (T8). For example, T5 appreciated the online system 批改网 (an online service system for automatically correcting English composition based on cloud computing) because "it makes it easy for us to share our students' papers and administrate students' writing portfolio". T5, as well as other teachers, interpreted and evaluated any new knowledge when learning it such as a technology. Teachers' cognition "shapes what teachers do but is in turn shaped by the experiences teachers accumulate" (Borg 2003, p. 95). The EFL teachers' evaluation results above are connected to teachers' CK, PK and PCK. The outcomes of their innovative technological pedagogy are mediated by teachers' experience and the knowledge accumulated and thus agree with Saudelli and Ciampa's finding (2014).

Fourthly, teachers' demographic background, such as age and the years of teaching experience, could also impact the degree to which technology is utilized. T7 asserted, "I have enough teaching materials. I don't have the desire to apply more technology since I'm about to retire". T7's reluctance to seek additional digital resources or learn new technology would surely become a barrier for developing her TK and other TK-integrated knowledge, because motivation plays a crucial role in enhancing the autonomy to develop TK (Banditvilai, 2016). As a veteran teacher, T7 was confident she already had rich materials. Her reluctance was also directly linked to the approach of her retirement in two years. Her attitude toward technology became the strongest barrier preventing her from utilising the technology which supports the other research findings (Ertmer, 2012; Liu et al., 2014).

Lastly, lacking quality training in technology was the factor that significantly influenced the development of EFL teachers' TPACK. Few teachers had received quality formal training in technology, and available training was mostly offered by publishers or software providers as one-shot workshops for marketing purposes (e.g., T2, T4, and T7), lacking attention to how to apply the technology as an effective pedagogical tool to represent content knowledge. Only T6 and T8 reported their recent reception of professional training in technology. T6 agreed that training opportunities were not open to everyone in her school and that access to these was on a competitive basis. By contrast,

T8 and her colleagues were the lucky ones who could access regular, unrestricted training in technology, offered by the School of Computer Science in their university. For the other seven interviewees, 'informal learning' was found to be the predominant way for them to develop their TK for their teaching needs, with the most popular ways being self-learning through use (T1, T3, and T9), and learning from available people via teachers' own learning networks, such as colleagues (e.g., T4, T5, and T7), family members (e.g., T4 and T7) and students (e.g., T5 and T7).

The lack of professional training in technology was likely to negatively influence these EFL teachers' attitudes toward technology, and their confidence in developing TK and teaching with technology. As Hong (2010) argues, computer-assisted language teacher education programs have noticeable benefits in building up teachers' positive attitudes towards technology and developing their confidence in technology competency; and the influencing factors contributing to language teachers' integration of technology into their teaching practices can be categorized as "teacher education, teachers' individual factors, and contextual factors", with teacher education, among these, being the most "salient" (p.60).

The ways that most interviewees sought to develop their TK reflect teachers' constructivist-oriented beliefs. According to Loughran (2013), pedagogy in constructivist learning is "both generative and informing as a consequence of an active and ongoing process" and is enhanced through noticing (p. 122). The interviewees' approaches to TK development mirror these key principles of constructivist learning in noticing the value of new technologies, learning by doing, regulating one's own learning, building individual meaning in a situation or experience, and learning with and from others. This aligns with the findings in Xiang and Ning's (2014) study that TPACK construction requires more of teachers' constructivist pedagogical beliefs than of traditional ones. Similarly, infusing technology innovation into content instruction (TCK) was often a personal adventure for these EFL teachers, which included dealing with an explosion in the availability of resources. As language teachers, they need to ensure the full integration of online materials with the subject (Banditvilai, 2016). EFL teachers also need to think about whether technology can be a useful pedagogical tool with suitable methods and activities, including for students' independent study outside classes. This time-consuming process is likely discouraging for EFL teachers (such as the participants in the present study), since many of them already have very heavy workloads (e.g., T5 and T7), negatively influencing the development of teachers' technological knowledge and TPACK.

## 4. Discussion

The survey respondents highly valued PK, CK and PCK in achieving successful EFL teaching but considered TK as the least important of all the seven TPACK components, as did the interviewees, who showed much more confidence in these three knowledge areas. This concurs with previous survey findings (Alqurashi, Gokbel, & Carbonara, 2017; Archambault & Crippen, 2009; Ekrem & Recep, 2014) that teachers have high confidence in PK and CK but less in TK. This finding also aligns with Xiang and Ning's (2014) finding that teachers are most competent in CK and familiar with traditional teaching modes without technological applications. These, and the findings of the present study appear to demonstrate that (both pre- and in- service) teachers generally agree with each other in viewing and developing PK, CK and PCK as the key knowledge components for achieving successful teaching in any discipline, even though in the digital era. This demonstrates that developing teachers' TPACK is "a multigenerational process" (Mishra & Koehler 2006, p. 1043).

In general, teachers' manner of using technological applications was expressive and informative but basic, lacking application purposes for communication, recreation, instruction and expansion. Therefore, the interplay of their TK with CK (TCK) and PK (TPK), and TPACK performance, although evident, was not significant, as evident in the results across both the survey and interview data. The survey respondents considered TK and other TK-integrated knowledge components (e.g., TCK and TPK) as being less important. Similarly, although all interviewees commonly adopted digital tools to assist their EFL teaching, no one described his/her technology competence as 'confident', but instead as "above average" (four teachers) or "unconfident" (five teachers). This limitation in TPACK development is probably interrelated to teachers' insufficient confidence in technological applications, which is "the necessary first step" to expand language teachers' TPK and use of technology as a pedagogical tool to enhance classroom teaching (Hong 2010, p. 56). This constraint on TPACK development also echoes Archambault and Crippen's (2009) findings on the minimum relationship

between teachers' TK with PK and CK, and on teachers' lack of confidence when teaching with technology.

Factors revealed to be contributing to interviewees' TPACK performance include both external and internal ones. The external factors were contextualized, such as the availability of technology equipment (T2) and internet accessibility (T7) at teaching venues, and decision-makers' beliefs, requirements and financial support to purchase updated digital tools and provide professional training (T6); or they were related to teachers' own learning networks for accessing support for technology (e.g., T4, T5 and T7). The importance of context is apparent throughout (Loughran, 2013). Internal factors were shown to be mainly linked to teachers' knowledge of students, teachers' demographic background (e.g., age, which was also evidenced in the survey), and teachers' constructivist-oriented beliefs, aligning with previous findings (Xiang & Ning, 2014). These findings support Sansom's (2020) argument that teacher change is dependent on each teacher, on each innovation, and in each context. The development of teachers' tech-integrated ability can be limited by the technology resource constraints in their teaching contexts or by their students' readiness (Dalal et al., 2021). Similarly, according to Mishra and Koehler's (2006) "context bound" notion of TPACK construction, applying technology in the classroom relies on certain factors, such as the availability of digital resources and student background.

Therefore, teachers' knowledge of students has a significant impact on TPACK construction and should be attended to as a key knowledge component in achieving successful teaching with technology. Nezvalová (2011) argues that, in developing PCK, the knowledge of students is even more significant than PK: Any embedded attribute of PCK (e.g., context, assessment, pedagogy) can be applied if a teacher has developed a solid knowledge of his/her students. The development of teachers' PK and CK must occur in the contexts of students and the learning environment (Dalal, 2021). In accordance with this consideration, the process of integrating TK with PCK to develop (EFL) teachers' TPACK and enhance technological innovation is both contextualized and dependent on teachers' knowledge of students.

## 5. Conclusion

This study explored EFL teachers' perceptions of the knowledge components (PK, CK, TK, PCK, TCK, TPK, and TPACK) in forming their own TPACK as well as their self-assessment of TPACK. The interviewees' self-evaluation results on their TPACK competency were found to be generally consistent with the role of each TPACK component that was perceived by survey respondents, even though the interviewees were all veteran teachers and their demographic backgrounds were not as various as the survey participants.

It is argued that the change process for experienced teachers may be "more complex, more varied and less certain" (Sansom 2020, p. 467) because teachers' beliefs about teaching and learning and their teaching experience influence each other (Shi et al., 2019). The present study has a limitation in that its interview participants were veteran teachers only, and also that the number of survey participants was too small to confidently generalize. However, since the survey participants' beliefs about the value of each TPACK component were in line with veteran teachers' (interviewees) self-evaluation results of their TPACK performance, this demonstrates the power of teacher cognition in shaping their practices (Borg, 2003) and, ultimately, their TPACK outcomes. This may imply that: 1) EFL teachers, regardless of their teaching experience, value CK, PK and PCK as the key knowledge components in achieving successful EFL teaching; 2) this strong belief drives their efforts to develop these knowledge areas, and their confidence in these areas is more developed with accumulated experience (such as for the interviewees); and 3) TK and the knowledge areas integrating with TK (TCK, TPK, and TPACK) are considered as less important, and accordingly, EFL teachers are relatively less confident in these areas. This evidences that teachers' positive beliefs about technology as a useful pedagogical tool in supporting students' learning development are the basis of succeeding in any tech-assisted instruction (Ertmer, 2012; Liu et al. 2014; Wozney et al., 2006). Enabling teachers to accept and obtain TK and to gain confidence to integrate it into their classroom teaching is "the unlimited goal" of teacher education in computer-assisted language learning (Hong 2010, p.53).

This study has implications for future research on teachers' TPACK and technological innovation in education. Firstly, certain policies can be made at the university/school levels to motivate technology-enhanced teaching (to accommodate the national CECR innovation goal). Secondly,

adequate financial support should be assigned to upgrade the technological equipment at teaching venues and to provide professional training in new technologies. The effectiveness of technological training in developing teachers' TPACK is apparent (e.g., Dalal, Archambault, & Shelton, 2021; Hong, 2010; Liu & Kleinsasser, 2015). Thirdly, technological training should be integrated with CK and/or PK. Unless equipped with a well-developed knowledge of computer-assisted language learning, language teachers find it difficult to make a difference through infusing technology into their classroom teaching (Hong, 2010). Training with educative examples could encourage teachers to explore the possibilities of new technology in their teaching; and teachers who learn about technology with the integration of CK may be more likely to apply this to support content learning, in comparison with learning it as a skill only (Hughes, 2005). In addition, the learning/training in technology and development of TPACK is continuing; and in this process, collaborative learning can be a useful way to learn technology and to develop TPACK (Hughes, 2005; Liu & Kleinsasser, 2015; Liu et al., 2014).

### Declarations

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|---|---|---|
| **Author contribution** | : | Leimin Shi was responsible for the entire research project. She also led the writing of the manuscript and the collaboration with the second author. Lili Jiang participated in the data collection, transcription and analysis. She also revised the manuscript. Both authors approved the final manuscript. |
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