Pre-service teachers' perceptions of technological pedagogical content knowledge in mainland China: A survey of teachers of Chinese as a second language

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Abstract

There is an urgent need to address the critical demand for qualified Chinese language teachers against the background of China's seeking greater Sino–foreign cultural and educational cooperation. The literature on integrating technological pedagogical content knowledge (TPACK) in language teaching has been increasing in the last few years. However, most of these studies focus on English language teachers. The objective of this study was to examine pre-service teachers' understanding of TPACK for teaching Chinese as a second language (TCSL). This study investigated the TPACK factor structure of 286 pre-service TCSL teachers via exploratory factor analysis, which yielded a six-factor structure. The results revealed that the teachers could not distinguish the boundaries between technological pedagogical knowledge (TPK) and technological content knowledge (TCK); and TPK and synthesized TPACK. Further, confirmatory factor analysis using structural equation modeling substantiated the validity and reliability of the adapted 32-item TCSL-TPACK survey instrument. The study also found that the teachers were slightly satisfied with their overall TPACK but were least confident of their technological knowledge (TK), and the more experienced teachers exhibited higher confidence in all six factors. These findings not only remind educators and policymakers of the need to revise current teacher training programs but also persuade TCSL student teachers to explore methods that can help integrate technology into lesson designs.

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1 Introduction

In 2019, two significant educational development plans were made public by the Chinese central government, thereby setting the direction for the education for sustainable development (ESD). These are China's Education Modernization Plan 2035 (Xinhua News Agency, 2019a) and the Implementation Plan for Accelerating Education Modernization (2018–2022) (Xinhua News Agency, 2019b). One of the core strategic tasks of the China's Education Modernization Plan 2035 is to create a new prospect of opening up to the world in education, for instance, by attracting international talents and overseas students to come to China, and speeding up the construction of overseas international schools (Xinhua News Agency, 2019a). Under the Implementation Plan for Accelerating Education Modernization (2018–2022), China is seeking greater Sino-foreign cultural and education cooperation under the "Belt and Road" initiative, by enhancing the distribution of Confucius Institutes and Classrooms, and improving the international education in Chinese language (Xinhua News Agency, 2019b). As of 2018, 548 Confucius Institutes and 1,193 Confucius Classrooms had been set up in more than 150 countries and regions (Gong et al., 2020b). The past few years have witnessed a steady increase in the number of people studying the Chinese language in various schools worldwide because of its increasing strategic importance. Therefore, there is an urgent need to address the critical demand for qualified teachers of the Chinese language (Zhang et al., 2020). In the past five years, the number of "teaching Chinese as a second language" (TCSL) programs in mainland China has increased significantly, with the numbers of universities offering TCSL in master and bachelor programs reaching more than 150 and 350, respectively. The students enrolled in these programs account for more than half of the volunteer Chinese language teachers. These volunteer teachers are generally selected and trained by the Center for Language Education and Cooperation, which was originally known as Hanban or Confucius Institute Headquarters. After receiving a four-week training, they travel abroad to teach Chinese at a variety of schools worldwide.

The rapid development of science and technology has led to new competency requirements for pre-service TCSL teachers. The COVID-19 outbreak also presents new challenges for these teachers. To prevent the spread of the virus, a majority of face-to-face TCSL classrooms have been replaced by online teaching via platforms such as Zoom, Skype, and Tencent Conference (Liu et al., 2020). Before the pandemic, many language teachers were reluctant or even refused to use technology-assisted teaching approaches (Toffoli & Sockett, 2015). Now however, the capacity to integrate information and communication technology (ICT) with teaching practice has become a critical competency for pre-service teachers (Chai et al., 2020). This integration is dependent on the process teachers use to conceptualize and implement technological pedagogical content knowledge (TPACK; Mishra & Koehler, 2006)). The TPACK framework has received significant attention from educators and researchers. About 600 publications on TPACK were indexed in the Scopus database from 2011 to 2019 (Tseng et al., 2020).

Many of these studies are predominantly focused on domain-general rather than domain-specific TPACK. Among these, about 51 publications on language teaching are available on the Web of Science and Scopus database. The majority of these publications examine English teachers' perceptions of TPACK (Tseng et al., 2020). Interestingly, while most Chinese mainland journal articles revolve around issues related to TCSL, such as teaching materials, methods, and strategies, international journals are more interested in research issues related to ICT integration in TCSL instructions (Gong et al., 2018). The use of technology in TCSL is still in its infancy (Lyu & Qi, 2020). Only five out of 60 papers in five leading Chinese mainland journals from 2014 to 2018 have dealt with TCSL teacher development, and most of them focused on in-service teachers (Gong et al., 2020a).

Many journal articles reiterate that more research on the nature of pre-service TCSL teachers' TPACK is needed, especially in mainland China. To accommodate this requirement for more literature, this paper used a questionnaire survey to collect quantitative data from 286 pre-service TCSL teachers. To further examine the participant teachers' TPACK constructs, the data were analyzed through exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). This study makes several contributions to the field of research. First, there are no known survey studies on TPACK of pre-service TCSL teachers in mainland China. This is the first of its kind. Second, the results of this study shed light on the current condition of pre-service TCSL instruction in mainland China and offer new insights on ways to improve current TCSL training programs. Finally, the findings of this study may encourage all parties involved—students, teacher educators, policymakers, and researchers—to support TCSL student teachers' TPACK training and consequently, their professional development.

2 Literature Review

2.1 A Domain-general Assessment of Pre-service Teachers' TPACK

TPACK is a conceptual framework for understanding how technology can be integrated effectively into classrooms (Koehler & Mishra, 2009; Shulman, 1986). The TPACK constructs are composed of seven forms of knowledge, including three primary knowledge forms, (content knowledge (CK), pedagogical knowledge (PK), and technological knowledge (TK)), three derived knowledge forms (pedagogical content knowledge (PCK), technological content knowledge (TCK), and technological pedagogical knowledge (TPK)), and a synthesized knowledge form (TPACK) (Mishra & Koehler, 2006)). A considerable body of research on the assessment of TPACK was mainly conducted through surveys, interviews, observations, and performance assessments. Among these approaches surveys were the most reported research instrument (Koehler et al., 2012). The most widely used survey instrument is the questionnaire developed by Schmidt et al. (2009) for pre-service teachers; it was used to measure 124 American pre-service PK-6 teachers' TPACK. Among all seven knowledge factors, TPK was perceived to be the highest, whereas TK and PCK were perceived to be the lowest. Significant correlations were found between the six subscales and TPACK. Three pairs of knowledge

had the highest correlations: TPK and TPACK; TCK and TPACK; and PCK and TPACK (Schmidt et al., 2009). Several subsequent studies modified Schmidt et al.'s survey to examine pre-service teachers' TPACK (Chai et al., 2010; Chai et al., 2011a, 2011b; Chaiet al., 2013b; Dong et al., 2015; Koh et al., 2010; Xiong et al., 2020). Koh et al. (2010) examined 1,185 Singaporean pre-service teachers' TPACK. Their analyses yielded five distinctive constructs: CK, TK, KP (knowledge of pedagogy), KTT (knowledge of teaching with technology), and KCR (knowledge from critical reflection). The participants could not distinguish between TPK, TCK, and TPACK, and the items of these constructs were loaded as KTT. Chai et al. (2010) investigated 889 Singaporean pre-service teachers' TPACK development. Their results indicated that CK, PK, and TK positively influenced these teachers' TPACK, with PK having the greatest effect. The participants' perception of TK was the lowest in both pre-and post-ICT training. Chai et al. 2011b) also examined 834 pre-service teachers' TPACK development in Singapore. The EFA results yielded only five factors, excluding TCK and PCK. TK and TPK were found to predict TPACK positively and significantly in the pre-course and post-course models.

The above-mentioned studies indicate that pre-service teachers could not clearly perceive the differences between TCK, PCK, and TPK. Several previous studies by Chai and colleagues have successfully extracted seven TPACK factors (Chai et al., 2011a; Chai et al., 2013b; Dong et al., 2015; Xiong et al., 2020). Eight knowledge factors were obtained through EFA by Chai et al.(2011a), including the seven original TPACK constructs and two partitioned CK constructs associated with two teaching subjects. Their results indicated that the Pearson's correlations of all the factors were positive and significant, except for TK and PCK. The instrument developed by Chai et al. (2011a) was adapted to assess the TPACK of pre-service teachers from Singapore, Taiwan, Hong Kong, and mainland China. All seven factors were identified in this study. The results suggest that the three primary knowledge factors had no direct effect on TPACK, while all seven factors were positively correlated with each other (Chai et al., 2013b). Dong et al. (2015) adapted the instrument used by Chaiet al. (2013b) to examine 784 pre-service and in-service teachers' TPACK in China. They successfully extracted seven TPACK constructs. Significant positive correlations were found among all the TPACK factors. TCK and TPK showed the strongest correlation with TPACK. Furthermore, the direct effects of CK, TCK, and TPK on TPACK were significant. In a recent study, Xiong et al. (2020) investigated the perceived TPACK of 807 Chinese pre-service teachers. Their results yielded all seven constructs. The study participants rated CK and TK the lowest.

In summary, these earlier studies demonstrate the reliability and validity of the survey instrument used by Chai and colleagues. Moreover, these instruments best fit the Asian context (Dong et al., 2015). However, the number of constructs extracted through EFA ranged from four to seven, indicating the complexity of these knowledge components.

2.2 TPACK Assessment in Language Teaching

The TPACK framework is increasingly being used in research on teacher education, but its application to studies on language teaching is lagging behind

those on other subjects by more than five years (Tseng et al., 2020). Most of these studies were conducted from English language teachers' perspectives (Baser et al., 2016; Bostancıoğlu & Handley, 2018; Tseng et al., 2011; Wu & Wang, 2015).

Tseng and colleagues conducted two qualitative studies to explore Taiwanese language teachers' perspectives about TPACK. Tseng et al. (2011) reported that junior high school teachers, who taught English as a foreign language (EFL), demonstrated knowledge of technology integration into traditional teaching strategies. They also found that Taiwanese TCSL teachers' TPACK grew with their increased understanding of ways to facilitate students' language acquisition with the help of internet resources (Tseng et al., 2016). Similarly, Wu and Wang (2015) used mixed methods to explore elementary school EFL teachers' TPACK in Taiwan. Their analyses indicate that the participants were most confident of their PK but least confident of their TK. Their qualitative data shows that teachers used technology mainly to motivate students to learn English. Baser et al. (2016) designed a 50-item instrument to assess TPACK in 378 Turkish pre-service EFL teachers. They conducted two rounds of EFA. In the first round, TCK, TPK, and TPACK were loaded as a single factor. The revision of the survey items resulted in a seven-factor structure in the second round; however, three TPACK items were loaded onto the TPK. Their results showed that pre-service teachers encountered difficulties in distinguishing between TCK, TPK, and TPACK. Bostancioğlu and Handley (2018) also introduced a new survey instrument to measure 542 EFL teachers' TPACK in 72 countries. Their analyses produced six TPACK factors. PK and PCK were merged as a single factor. Strong correlations were found between TPK and TCK; TPK and TPACK; and TCK and TPACK. Chai et al. (2013a) measured 349 in-service Chinese language teachers' TPACK in Singapore. The EFA yielded all seven factors of the TPACK. The participants were more competent in CK and PK than in TPACK and TCK. The correlations of all the factors were positive and significant, except for PCK and TCK; and PCK and TPACK. Cheng (2017) examined how in-service Hakka language teachers perceived their TPACK and found that these teachers were generally content with their TPACK, but they were relatively less competent in TK, TPK, and CK.

Two studies investigated students' understanding of their language teachers' TPACK. Tseng (2016) developed a survey instrument to examine 257 junior high school students' understanding of their English teachers' TPACK. Their results yielded only five factors: TK, TPK, PCK, TCK + TPACK, and PK + CK, indicating that the participants could not clearly separate the boundaries between some TPACK factors. Chuang et al. (2018) surveyed 287 students from four classes of English teachers. Their results showed that English teachers' TK and knowledge of students' understanding directly influenced their TPACK.

In summary, the current literature concerning TPACK assessment in language teaching shows that both teachers and students may find it difficult to discriminate among the TPACK constructs. Thus, survey items should be contextualized with context-specific pedagogy and technology.

2.3 Relationships between Demographic Variables and Teachers' TPACK

Some background variables, such as gender, age, teaching level, and years of teaching, may influence both pre-service and in-service teachers' TPACK. In terms of gender difference, some studies reported that female teachers usually exhibit lower confidence levels in technology-related knowledge, such as TK, TCK, and TPACK, than male teachers (Cheng, 2017; Koh et al., 2014; Roig-Vila et al., 2015) but have higher levels of PK (Lin et al., 2013) or CK (Cheng, 2017). However, research on physics instructors indicated no statistical significance in overall TPACK based on gender (Jang & Chang, 2016). Age and teaching experience are two variables that might also affect teachers' understanding of TPACK. Past evidence has shown that older, more experienced teachers tend to have lower ratings of the constructs related to technology (Lee & Tsai, 2010; Yaghi, 2001). Experienced teachers generally have higher levels of CK and PK (Jang & Chang, 2016). Lee and Tsai (2010) concluded that teachers with more years of teaching had lower competence in using web technology and in incorporating web technology into teaching. In Cheng's (2017) study, no correlations were found between the participants' ages and their TPACK. Further analyses indicated that older female teachers were relatively less confident in TK. In addition, participants with more teaching experience demonstrated more confidence in CK, PK, and PCK.

Based on the literature reviewed above, the current study would like to investigate the following questions:

- What are the various TPACK factors observed in pre-service TCSL teachers?
- Is the adapted TCSL-TPACK survey instrument valid and reliable for pre-service TCSL teachers?
- What is the relationship between demographic variables of pre-service TCSL teachers and their perceived TPACK?

3 Methods

3.1 Participants

The participants of the present study were 286 TCSL students from at least 20 provinces in mainland China, 22 males (7.69%) and 264 females (92.31%). There were 55 undergraduate students (19.23%) and 231 (80.77%) master's students. Among the master's students, 175 students (61.19%) had a bachelor's degree in Chinese literature, Chinese language, and TCSL; 29 students (10.14%) held a bachelor's degree in English or other foreign languages, and 27 (9.44%) had a bachelor's degree in other disciplines.

Since the 1980s, "teaching Chinese as a second or foreign language" (TCSL/ TCFL) has been widely used in China. In 2007, the Ministry of Education established the "Master of Teaching Chinese to Speakers of Other Languages" (MTC-SOL). In 2012, teaching Chinese to speakers of other languages (TCSOL) was

included in the catalog of undergraduate majors. Both the undergraduate and master's programs mainly recruit Chinese students (Li, 2014). It should be noted that TCSL/TCFL has still been the most frequently used term in international journals. The change from TCSL/TCFL to TCSOL mainly reflects the development of international Chinese language education. According to the Standards for Teachers of Chinese to Speakers of Other Languages published by Hanban in 2015, a framework of knowledge, abilities, and qualities that are required of a qualified Chinese language teacher has five components: basics in Chinese language teaching, Chinese teaching methodology, instructional design and classroom management, Chinese culture and intercultural communication, and professional ethics and disciplinary development (Hanban, 2015). It should be pointed out that in recent years the number of non-TCSL undergraduates applying for TCSL master programs have greatly expanded partly due to the soaring demand for Chinese language teachers.

The survey instrument used in this study has 32 items. Thus, the ratio of observations to the variables of the study was 8.94. The number of participants in this study satisfied the minimum ratio of observations to the variables for purposes of factor analysis. Regarding the ratio of observations to the variables, the general rule is to have a minimum 5:1 ratio, and a more acceptable sample size would have a 10:1 ratio (Hair et al., 2018).

3.2 Instrument

The survey instrument used in this study was adapted from several sources. Instruments developed by Chai et al. (2013b), Koh et al. (2010), Bostancıoğlu and Handley (2018), and Hanban (2015) influenced the design of the questionnaire used in this survey. Initially, 42 questionnaire items were generated. The authors then consulted two experts in the field of TCSL regarding the quality of the questionnaire. We also asked five TCSL master's students for assistance with the design and wording of the items. After receiving feedback from experts and students, some items from the initial survey instrument were revised for better contextualization of the teaching approaches, particularly regarding technology. After modifications and eliminations, 32 items were included in the final survey (i.e., the TCSL-TPACK). The number of items for each factor was four (CK), five (PK), five (TK), four (PCK), five (TCK), five (TPK), and four (TPACK). According to Weng (2004), providing more options in the survey instrument can generate more reliable participant responses. Hence, each item of the TCSL-TPACK was rated on a seven-point Likert scale (1 = strongly disagree; 7 = strongly agree). See Appendix A for the TCSL-TPACK survey items.

3.3 Data Collection and Analysis

The TCSL-TPACK survey was conducted using Wenjuanxing, a web-based survey tool (Zhang et al., 2020). Data were collected using the convenience sampling

method. Each respondent took about eight minutes to complete the questionnaire. To ensure anonymity, the names of the participants were not collected. However, demographic information about gender, grade, major, length of teaching experience, and technology courses, were collected during the survey. EFA of the 32 items was conducted using a varimax rotation in SPSS 21 (Field, 2009). The factors in the EFA were checked based on two basic requirements. The eigenvalues of the factors should be greater than 1.0, and the initial factor loading of the survey items should be greater than 0.5 (Field, 2009; Hair et al., 2018). The factors produced by the EFA were then examined through CFA in AMOS 24 with maximum likelihood estimation.

4 Results

4.1 Exploratory Factor Analysis and Descriptive Statistics

To check whether the sample size was adequate and the survey items were correlated, KMO and Bartlett's tests were first run in SPSS. The results of the two tests (KMO = 0.95, χ^2 [465] = 6048.48, $p < 0.0001$) indicated that the data met the requirements of the subsequent factor analysis (Beavers et al., 2013; Bostancıoğlu & Handley, 2018). From the EFA results, 31 items were retained, accounting for 68.39% of the total variance. Only one item in TK (TK5), with an initial factor loading below 0.5, was deleted. The factor loadings of these items are listed in Table 1, where the items are classified into six factors. Four factors (CK, PK, TK, and PCK) emerged as their original constructs. The TPK items loaded onto TCK and TPACK. Thus, the combination of TPK and TCK was labeled TCK, and the combination of TPK and TPACK was labeled TPACK. It appears that the EFA resulted in the loss of the TPK factor.

The Cronbach's alpha reliability coefficient was utilized to check the survey's internal consistency. The overall Cronbach's alpha for the 31-item survey was 0.96. Table 1 shows the Cronbach's alphas of the six TCSL-TPACK factors as follows: CK, α = 0.85; PK, α = 0.89; TK, α = 0.79; PCK, α = 0.91; TCK, α = 0.88; and TPACK, α = 0.90. The coefficients of the survey and its subscales are all above 0.70, which is sufficient for internal consistency (Chuang et al., 2018). Thus, the reliability of the TCSL-TPACK survey for assessing the participants' perceptions of TPACK was confirmed.

On the whole, pre-service TCSL teachers were slightly confident of their TPACK, as the overall mean score was 5.05 (SD = 1.15), very close to 5 ('slightly agree') out of a seven-point scale. The mean scores for the six subscales ranged from 4.61 to 5.43 (see Table 1). Among all the factors, TCK received the highest score (M = 5.43; SD = 0.81), indicating that the participants were highly confident of their TCK. Perception of TPACK (M = 5.19; SD = 0.83) was slightly above the overall mean. Pre-service TCSL teachers perceived themselves as capable of using the software developed for Chinese language teaching or learning (TCK1: M = 5.72; SD = 1.09) and of using suitable technologies to present Chinese language content (TCK2: M = 5.51; SD = 1.04). The participants also knew how to use internet search engines to prepare

Table 1 Factor Loadings, Cronbach's Alpha Coefficients, and Mean Values for the TCSL-TPACK Survey

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Mean	SD
CK, α=0.85							*4.91*	*0.94*
CK1	0.70						4.95	1.07
CK2	0.66						4.97	1.14
CK3	0.65						5.07	1.17
CK4	0.59						4.65	1.15
PK, α=0.89							*4.91*	*0.89*
PK1		0.70					4.88	1.02
PK2		0.71					5.08	1.06
PK3		0.80					4.98	1.02
PK4		0.73					4.84	1.09
PK5		0.61					4.78	1.09
TK, α=0.79							*4.61*	*0.96*
TK1			0.55				4.71	1.13
TK2			0.62				4.49	1.12
TK3			0.79				4.04	1.48
TK4			0.54				5.22	1.22
PCK, α=0.91							*4.92*	*0.98*
PCK1				0.71			4.88	1.13
PCK2				0.79			5.02	1.14
PCK3				0.81			4.77	1.14
PCK4				0.76			5.00	1.03
TCK, α=0.88							*5.43*	*0.81*
TCK1					0.67		5.72	1.09
TCK2					0.73		5.51	1.04
TCK3					0.55		5.21	0.96
TCK4					0.71		5.35	1.05
TCK5					0.51		5.11	1.17
TPK1					0.72		5.78	1.01
TPK2					0.58		5.31	1.04
TPACK, α=0.90							*5.19*	*0.83*
TPACK1						0.68	5.06	1.01
TPACK2						0.67	5.20	0.91
TPACK3						0.72	5.14	0.96
TPACK4						0.62	5.00	1.02
TPK3						0.60	5.44	1.23
TPK4						0.65	5.20	1.13
TPK5						0.61	5.28	1.10

teaching materials (TPK1: M=5.78; SD=1.01). They were slightly confident about teaching online (TPK3: M=5.44, SD=1.23; TPK5: M=5.28, SD=1.10) and promoting students' online learning (TPACK3: M=5.14; SD=0.96). The pre-service TCSL teachers' rating of TK (M=4.61; SD=0.96) was the lowest among all

factors. The participants were least sure about how to use software (e.g., SPSS and Excel) to analyze data (TK3: M = 4.04; SD = 1.48). They had very low confidence in their ability to solve technical problems on their own (TK2: M = 4.49; SD = 1.12) and to learn technology easily (TK1: M = 4.71; SD = 1.13). The participants' ratings for the three non-technology-related forms of knowledge were almost the same (CK: M = 4.91, SD = 0.94; PK: M = 4.91, SD = 0.89; PCK: M = 4.92, SD = 0.98). All scores were less than five points.

Pearson correlation analysis was performed to examine the relationships between the six TCSL-TPACK factors. Table 2 shows that all the subscales are significantly correlated with each other, with the correlation coefficients ranging from 0.54 to 0.76. Almost half of the Pearson correlations between the six subscales are strong. The correlation between TCK and TPACK ($r = 0.76$) is the highest, followed by that between CK and PK ($r = 0.71$). All correlations between the six TCSL-TPACK factors are significant and positive, indicating the logical consistency of the TCSL-TPACK model (Bostancıoğlu & Handley, 2018).

4.2 Confirmatory Factor Analysis

The EFA produced six factors for the TCSL-TPACK survey. Thus, a modified hypothesized model (see Fig. 1) is proposed based on the TPACK framework (Mishra & Koehler, 2006). The hypotheses are formulated as follows:

H1: CK significantly affects PCK in a positive way.
H2: CK significantly affects TCK in a positive way.
H3: CK significantly affects TPACK in a positive way.
H4: PK significantly affects PCK in a positive way.
H5: PK significantly affects TPACK in a positive way.
H6: TK significantly affects TCK in a positive way.
H7: TK significantly affects TPACK in a positive way.
H8: PCK significantly affects TPACK in a positive way.
H9: TCK significantly affects TPACK in a positive way.

Table 2 Correlations between the TCSL-TPACK Subscales

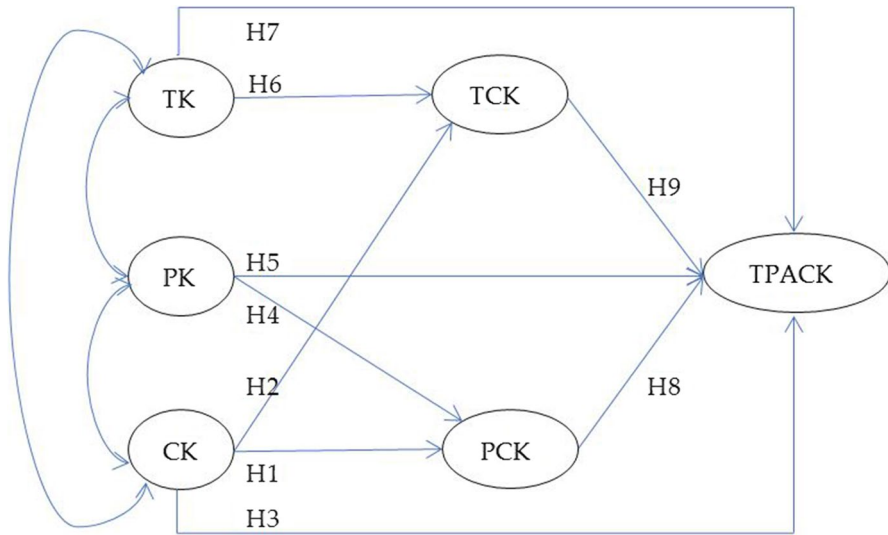|	CK	PK	TK	PCK	TCK	TPACK
CK	1					
PK	0.71[**]	1				
TK	0.56[**]	0.58[**]	1			
PCK	0.59[**]	0.61[**]	0.54[**]	1		
TCK	0.55[**]	0.57[**]	0.62[**]	0.56[**]	1	
TPACK	0.62[**]	0.61[**]	0.59[**]	0.61[**]	0.76[**]	1

** denotes significance at the 1% level

Fig. 1 Structural model of the TCSL-TPACK (adapted from Koh et al. (2013))

After the EFA, the data of the remaining 31 items were analyzed through CFA using AMOS 24. The fit indices generally used to assess the model fit are as follows: χ^2, CMIN/DF, RMSEA, SRMR, TLI, and CFI (Hair et al., 2018). The first attempt at CFA indicated that the model did not produce acceptable values based on the number of observations (>250) and observed variables (≥ 30). Although the model had acceptable RMSEA (0.068) and SRMR (0.063), the TLI and CFI were lower than 0.92. After repeatedly checking the modification indices, the residuals of some items were found to be correlated with each other, specifically, CK1 and CK2; and TPK3 and TPK4. The pre-service TCSL teachers with sufficient knowledge of the subject matter (CK1) tend to have enough confidence in teaching the Chinese language (CK2). Those who conduct online teaching (TPK3) might help their students in group work using technology (TPK4). The fit indices of the final model are acceptable. Figure 2 illustrates the final SEM diagram of the TCSL-TPACK survey. Table 3 lists the fit indices of the final model. It shows that the final model obtained a good or acceptable level of fit ($\chi^2 = 882.944$; $p < 0.001$; $\chi^2/df = 2.102$; RMSEA = 0.062; SRMR = 0.060; TLI = 0.912; and CFI = 0.921).

Table 4 displays the nine hypotheses and path coefficients of the final SEM for the TCSL-TPACK survey. As indicated in Table 4, only two of the nine hypotheses were not supported. The two primary knowledge factors, CK and PK, did not positively and significantly predict TPACK. Table 4 shows that CK and PK positively affected the derived factors of PCK; and CK and TK positively influenced the derived TCK factor. The results showed that pre-service TCSL teachers perceived three direct paths toward TPACK from TCK ($\beta = 0.53$), PCK ($\beta = 0.17$), and TK ($\beta = 0.14$), among which TCK had the largest path coefficient, indicating that it had a stronger effect on TPACK than TK and PCK did.
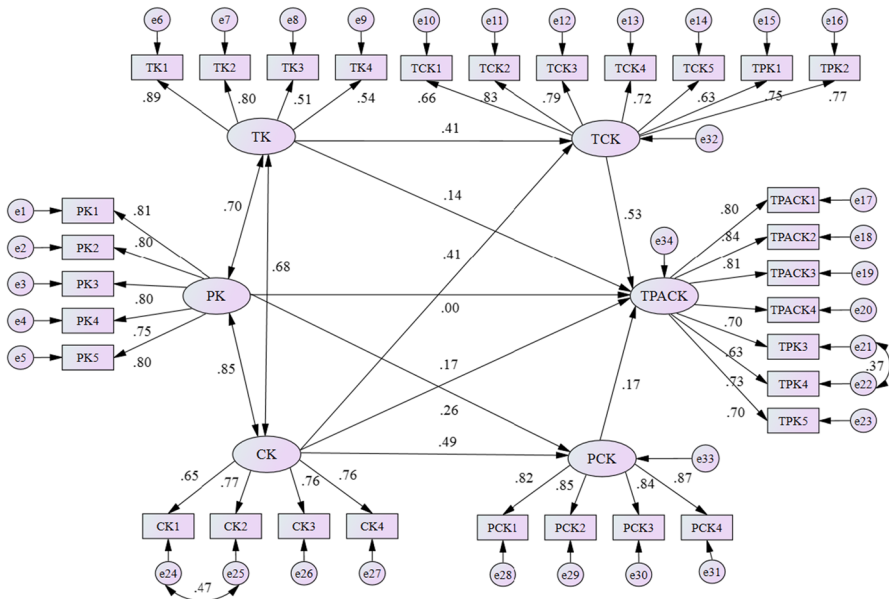
Fig. 2 Diagram of the SEM for the TCSL-TPACK survey

Table 3 SEM Model Fit Indices

Model	χ^2	χ^2/df	RMSEA	SRMR	TLI	CFI
Suggested	Significant p-values expected	< 2	< 0.07	< 0.08	> 0.92	> 0.92
TCSL-TPACK	882.944***	2.102	0.062	0.060	0.912	0.921
Result	Acceptable	Acceptable	Good	Good	Acceptable	Good

*** denotes significance at the 0.1% level

Table 4 The Hypotheses and Path Coefficients for the SEM of TCSL-TPACK

Hypotheses	β	S.E	C.R	Supported
H1: CK significantly affects PCK in a positive way	0.49	0.18	3.56***	Yes
H2: CK significantly affects TCK in a positive way	0.41	0.09	4.68***	Yes
H3: CK significantly affects TPACK in a positive way	0.17	0.14	1.39	No
H4: PK significantly affects PCK in a positive way	0.26	0.14	2.00*	Yes
H5: PK significantly affects TPACK in a positive way	0.00	0.10	0.04	No
H6: TK significantly affects TCK in a positive way	0.41	0.06	4.97***	Yes
H7: TK significantly affects TPACK in a positive way	0.14	0.06	2.00*	Yes
H8: PCK significantly affects TPACK in a positive way	0.17	0.06	2.70*	Yes
H9: TCK significantly affects TPACK in a positive way	0.53	0.09	6.72***	Yes

* and *** denotes significance at the 5% and 0.1% levels, respectively

4.3 Convergent Validity

Composite reliability (CR) and average variance extracted (AVE) were checked to verify the convergent validity of the structural model (Habibi et al., 2020). CR was used to measure internal consistency reliability, which, for factor analysis, should be above 0.60. A CR value between 0.70 and 0.95 is considered more desirable. The AVE was calculated by averaging the squared loadings of all the indicators associated with a particular construct. An acceptable value of AVE is 0.50 or higher, meaning that the construct can explain at least 50% of the variance of its indicators (Hair et al., 2018).

The standardized factor loadings of each item shown in Fig. 2 are presented in Table 5. These values were used to calculate CR and AVE for the six constructs. Table 5 shows CR values of 0.83 (CK), 0.89 (PK), 0.79 (TK), 0.91 (PCK), 0.89 (TCK), and 0.90 (TPACK). All these values are above 0.70 and below 0.95. All constructs have AVE values that are 0.50 or higher, specifically, 0.54 (CK), 0.63 (PK), 0.50 (TK), 0.71 (PCK), 0.55 (TCK), and 0.56 (TPACK), thereby explaining at least 50% of the variance of the items for each TCSL-TPACK construct. Therefore, all CR and AVE values of the six TCSL-TPACK factors met the conventional criterion, indicating that the final structural equation model is reliable and valid.

4.4 Correlations between Demographic Information and TCSL-TPACK Factors

Table 6 presents the background information of the participants. As shown in Table 6, the vast majority of the participants were female (92.31%), which is typical of the teaching population in TCSL. There were 240 participants (83.92%) with at least one month of teaching practice. With regards to the technology courses taken by the participants, above 50% of the participants had taken an introductory course on computers or educational technology. Only eight participants (2.80%) had attended an advanced course on computers. The number of technology courses was computed for further analysis. The results show that 144, 95 and 47 participants had completed one course (50.35%), two courses (33.22%), and three courses (16.43%), respectively.

Table 7 shows the correlations between the pre-service TCSL teachers' TPACK and their demographic information. First, as shown in Table 7, there were no correlations between the participants' gender and undergraduate major and the six TPACK factors. This suggests that the pre-service teachers' gender and undergraduate major had no effect on their perceived TPACK. Second, no significant correlations were found between the pre-service teachers' grades and the six factors, except for CK ($r = 0.14$, $p < 0.05$) and TPACK ($r = 0.15$, $p < 0.05$). The weak positive correlations between the participants' grades and their CK and TPACK indicate that the participants' CK and TPACK improved as their grade increased. Third, no significant correlations were found between the number of technology courses that the participants took and the six factors, except for TK ($r = 0.21$, $p < 0.01$), which

Factor	Item	Standardized factor loading	CR	AVE
Table 5 Standardized Factor Loadings, CR, and AVE of the SEM for the TCSL-TPACK Survey				
CK	CK1	0.65	0.83	0.54
	CK2	0.77		
	CK3	0.76		
	CK4	0.76		
PK	PK1	0.81	0.89	0.63
	PK2	0.80		
	PK3	0.80		
	PK4	0.75		
	PK5	0.80		
TK	TK1	0.89	0.79	0.50
	TK2	0.80		
	TK3	0.51		
	TK4	0.54		
PCK	PCK1	0.82	0.91	0.71
	PCK2	0.85		
	PCK3	0.84		
	PCK4	0.87		
TCK	TCK1	0.66	0.89	0.55
	TCK2	0.83		
	TCK3	0.79		
	TCK4	0.72		
	TCK5	0.63		
	TPK1	0.75		
	TPK2	0.77		
TPACK	TPACK1	0.80	0.90	0.56
	TPACK2	0.84		
	TPACK3	0.81		
	TPACK4	0.70		
	TPK3	0.63		
	TPK4	0.73		
	TPK5	0.70		

suggests that the more courses the pre-service TCSL teachers took, the higher TK they had. Finally, the results in Table 7 show positive relations between the length of TCSL teaching and all six TPACK factors, at a significance level of 0.01; specifically, CK ($r = 0.33$), PK ($r = 0.30$), TK ($r = 0.20$), PCK ($r = 0.30$), TCK ($r = 0.25$), and TPACK ($r = 0.28$). These results indicate that pre-service TCSL teachers who are more experienced are likely to exhibit higher self-confidence in their perceived TPACK.

Table 6 Demographic Information of the Participants

Information	Items	N	Percentage
Gender	Male	22	7.69%
	Female	264	92.31%
Grade	Undergraduate-Junior	23	8.04%
	Undergraduate-Senior	32	11.19%
	Master-Grade 1	98	34.27%
	Master-Grade 2	100	34.97%
	Master-Grade 3	33	11.54%
Undergraduate major	Chinese literature, Chinese language, and TCSL	230	80.42%
	English and other foreign languages	29	10.14%
	Other major	27	9.44%
Length of TCSL teaching (months)	None	46	16.08%
	1–3	92	32.17%
	4–6	39	13.64%
	7–12	54	18.88%
	Over 12	55	19.23%
Technology courses	Introductory course on computers	186	65.03%
	Advanced course on computers	8	2.80%
	Multimedia technology	81	28.32%
	Educational technology	146	51.05%
	Other technology courses	66	23.08%

Table 7 Correlations between Pre-Service TCSL Teachers' TPACK and Their Demographic Information

	Gender	Grade	Undergraduate Major	Length of TCSL teaching	Number of Technology courses
CK	0.02	0.14*	-0.08	0.33**	0.11
PK	0.06	0.08	0.01	0.30**	0.11
TK	0.08	0.03	-0.01	0.20**	0.21**
PCK	0.01	0.11	0.02	0.30**	0.08
TCK	0.09	0.12	0.01	0.25**	0.08
TPACK	0.11	0.15*	-0.05	0.28**	0.07

* and ** denote significance at the 5% and 1% levels, respectively

5 Discussion

The EFA results yielded a six-factor structure, including three primary knowledge forms (CK, PK, and TK), two derived knowledge forms (PCK and TCK), and a

synthesized knowledge form (TPACK). The analysis also found that the pre-service TCSL teachers could not distinguish the boundaries between TPK and TCK; and TPK and synthesized TPACK. The results of this study are similar to those reported by Koh et al. (2010) and Baser et al. (2016). These two studies also concluded that pre-service teachers were not able to make clear distinctions between the three technology-related constructs. The lack of clarity about the boundaries of each TPACK construct can make it difficult for pre-service or in-service teachers to identify the original seven constructs of the TPACK (Chai et al., 2011b; Cox & Graham, 2009; Koehler & Mishra, 2008). The wording of the survey items could also result in the mixing of TCK, TPK, and TPACK. In this study, three TPK items (TPK3, TPK4, and TPK5) were loaded onto the TPACK. All these three TPK items contained the word "online". Online technologies were also shown in some TPACK items (TPACK3 and TPACK4). Two TPK items that used terms like "prepare teaching materials" (TPK1) and "improve teaching approaches" (TPK2) were loaded onto TCK. A possible reason for this result is that the pre-service teachers were less competent in delineating the connections between subject content and pedagogy than experienced teachers (Koh et al., 2010). Although the participants in this study could differentiate between CK and PK, there was a strong correlation between these two constructs ($r = 0.71$). This suggests a possible explanation for the combination of TCK and TPK. That is, pre-service TCSL teachers might sometimes confuse CK with PK, especially when using technology.

This study found that although all the six knowledge forms are positively correlated with each other, CK and PK have no direct effects on TPACK. However, TK, PCK, and TCK positively and significantly affect TPACK. TCK has a stronger effect on TPACK than TK and PCK does. The greatest correlations are between TCK and TPACK, followed by CK and PK. These results are partly similar to those of previous studies (Chai et al., 2011b; Koh et al., 2013). In the pre-course model, pre-service teachers considered TK, PK, and TPK to be significantly linked to TPACK (Chai et al., 2011b). PK, TK, TCK, and TPK have direct positive effects on TPACK, among which TCK has the greatest effect on TPACK (Koh et al., 2013). Unlike previous studies, the current study found that PK has no direct effect on TPACK. Significant positive correlations among all TPACK constructs were also found in Dong et al.'s (2015) study. They found that TCK and TPK have the strongest correlation with TPACK. By contrast, Chai et al. (2013b) found that the three primary knowledge factors do not directly influence TPACK, while all knowledge factors are positively and significantly correlated.

Previous studies have shown that pre-service teachers generally rate their TK as the lowest among all TPACK factors (Chai et al., 2010; Schmidt et al., 2009; Wu & Wang, 2015). Similarly, Xiong et al. (2020) found that the study participants rated CK and TK the lowest. Cheng (2017) showed that the participants were less content with their TK, TPK, and CK. In this study, descriptive analyses showed that pre-service TCSL teachers are slightly content with their overall TPACK, but they are least confident of their TK. These findings are consistent with those of previous studies. The reason for this result could be because most of the study participants were female (92.31%). Previous studies have shown that female teachers usually are less confident in TK (Cheng, 2017; Koh et al., 2014;

Lin et al., 2013; Liu et al., 2015). As Table 1 shows, all the mean scores for the TK items are below the overall mean score (5.05), except for TK4 (M = 5.22; SD = 1.22). That is, pre-service TCSL teachers demonstrate high confidence in using basic applications for image, audio, and video files, but low confidence in using statistical software such as SPSS.

In line with previous studies (Chai et al., 2010; Chuang et al., 2018; Shih & Chuang, 2013), the current study also reveals that TK is a significant predictor of pre-service TCSL teachers' TPACK. This finding highlights the importance of integrating emerging technology into TCSL teacher education programs. It was presumed that all participants would be "digital natives," since they were aged between 21 to 25 years. Digital natives are those who grew up immersed in social media technologies (Prensky, 2001). Surprisingly, however, their ratings for TK were the lowest. This could be because female teachers are less confident of knowledge that involves technology, as compared to male teachers (Cheng, 2017). Given that the teaching profession is dominated by women (Organisation for Economic Cooperation and Development, 2017), there is an urgent need to teach pre-service TCSL teachers ways to integrate technology with subject content and pedagogy.

The correlations between pre-service TCSL teachers' background variables and their perceptions of TPACK were also analyzed in this study. Compared with the other variables, the length of teaching experience exerted greater influence on the participants' TPACK. The study found that the more experienced pre-service TCSL teachers were likely to exhibit higher confidence in all the six TCSL-TPACK factors. While this result is consistent with some of the previous studies (Cheng, 2017; Jang & Chang, 2016), they are in contrast to those of other studies. For example, Lee and Tsai (2010) reported that the more experienced teachers demonstrate lower self-efficacy in all the five aspects of web-related knowledge factors. A possible reason for this difference is that the participants of the current study were just undergraduate and master's students, while the participants in Lee and Tsai were in-service teachers whose ages ranged from 22 to 65, and had teaching experience of 1 to 40 years. The findings of this study are evidence that teaching experience can affect the pre-service TCSL teachers' TPACK development. Most young student teachers are willing to accept the unknown, which includes the integration of new technologies into teaching practices (So et al., 2012). Providing student teachers opportunities to carry out actual teaching practice may help them develop knowledge in content, pedagogy, and technology.

6 Conclusion and implications

The current study examined how 286 pre-service TCSL teachers perceive their TPACK and how background variables affect their TPACK. The main findings of this study are summarized here. First, the EFA results yielded a six-factor structure, but it also showed that the pre-service TCSL teachers could not separate the boundaries between TPK and TCK; and TPK and TPACK. Second, the application

of CFA and structural equation modeling proved that the adapted 32-item TCSL-TPACK survey instrument used in this study is valid and reliable. The analysis also found that although all the six knowledge constructs were positively correlated, CK and PK have no direct impact on TPACK. Furthermore, TK, PCK, and TCK can positively and significantly predict TPACK. Third, even though the pre-service TCSL teachers were slightly content with their overall TPACK, they still rated their TK as the weakest. The results also indicate that the more experienced pre-service TCSL teachers were more confident in all six factors.

The study has two important practical implications. The first implication concerns the revising of the current training program for pre-service TCSL teachers. Pre-service TCSL teachers' TPACK needs better support in teacher education. Previous studies have revealed that ICT training courses can raise pre-service teachers' TPACK (Chai et al., 2010, 2011b). However, there is only one provision regarding educational technology in the Standards for Teachers of Chinese to Speakers of Other Languages, which states that teachers should demonstrate knowledge and ability to apply modern educational technologies in the teaching of Chinese language (Hanban, 2015). Similarly, only one elective course called "Modern Educational Technology and Its Application in Teaching" was listed in the Training Program for Graduate Students with a Master's Degree in Teaching Chinese to Speakers of Other Languages (Office of Academic Degrees Committee of the State Council, 2007). Both these documents are not yet fully prepared to help teacher candidates adequately fuse technology into teaching and learning. Moreover, the courses on subject content, pedagogy, and technology are usually taught in isolation in most domestic universities. As a result, most TCSL student teachers might encounter problems comprehending the complex relationships between subject content, pedagogy, and technology. There is also evidence that student teachers might still have very limited knowledge in technology integration even after participating in instructional technology courses (Hew & Brush, 2007; Kabakci Yurdakul & Çoklar, 2014). Therefore, training programs must be revised to help pre-service TCSL teachers build not only knowledge of content, pedagogy, and technological skills, but also their understanding of the interaction between these areas (Tondeur et al., 2012; Valtonen et al., 2019). Furthermore, TCSL training programs could also offer novice pre-service teachers some courses or lectures based on the TPACK framework so that they can gain a deeper understanding of how to teach with specific technologies, such as web conferencing, social media, whiteboards, and blogs.

The second implication is a call for course materials to be reformed. It is essential to equip student teachers with the ability to integrate technology into curriculum design for purposes of enhancing TCSL teacher education programs. In this study, 65.03% of the participants had attended an introductory course on computers; 51.05% on educational technology; and 28.32% had taken a course in multimedia technology. While a majority of pre-service teachers have basic computer skills, they still might be inexperienced in designing technology-integrated lessons. Many studies have revealed that ICT-based lesson activities help

pre-service teachers develop their competency to incorporate particular web or technology-based tools into their teaching (Mouza et al., 2014; Özgün-Koca et al., 2010; Paneru, 2018; So & Kim, 2009; Tai, 2015; Tseng et al., 2016). These studies show that incorporating technology into the lesson plan designing might be a feasible means of assisting pre-service TCSL teachers in advancing TPACK. A learning-by-doing approach that involves five steps where instructors model, analyze, and demonstrate and participants apply and reflect seems promising for TPACK-based teacher education and professional development (Tai, 2015). A teacher support group model developed by Tseng et al. (2016) might also have significant implications for student teachers' online teaching development. In this model, language teachers collaborate with each other in four stages: understanding the TPACK framework, observing and adjusting instructions, and reflecting on their teaching (Tseng et al., 2016).

At present, more than half of first-year TCSL master's students at the authors' university are teaching Chinese language online, a widespread phenomenon in the field of TCSL since the outbreak of the COVID-19 pandemic (Yang, 2020). There is a critical need for educators and researchers to design TPACK-enhanced instruction suitable for TCSL students to prepare them for post-pandemic language classrooms.

7 Limitations

We acknowledge two limitations to the current study. First, data were collected using an online self-report questionnaire. Only 19.23% of undergraduate students participated in this study. Thus, the sample may not be representative of the TCSL students. Further study with a sample that includes more undergraduate students and that uses an on-site questionnaire is needed. A triangulated method with follow-up interviews can also be used in future studies. Second, considering the unclear boundaries between technology-related constructs, the language and wording of these questionnaire items should be further improved and clarified to be more reader-friendly.

Appendix A Items for TCSL-TPACK Survey

CK

(1) I have sufficient knowledge of Chinese language and culture (e.g., knowledge in Chinese linguistics, Chinese culture, and intercultural communication).
(2) I am confident that I will be a TCSL teacher.
(3) I can use various means (e.g., lectures, books, and teaching practices) to achieve a better understanding of the knowledge of Chinese language and culture.
(4) I can keep up with the latest developments in TCSL and think about its issues.

PK

(1) I can effectively organize and manage the classroom.
(2) I can use various teaching approaches in a classroom (e.g., grammar-translation, functional, and communicative approaches).
(3) I can adopt different teaching styles (e.g., motivational, enthusiastic, and humorous) based on the students' characteristics.
(4) I can apply various methods to monitor students' learning performance.
(5) I can expand students' thinking by creating challenging tasks for them.

TK

(1) I can learn technology easily.
(2) I can solve technical problems on my own when using technology.
(3) I can use software (e.g., SPSS, Excel) to analyze data.
(4) I can use basic applications for image, audio, and video files (e.g., Photoshop, Meitu, Butter Camera, and Jianying).
(5) I can use basic office applications (e.g., Word, Excel, and PPT)

PCK

(1) Without using technology, I can select suitable and effective teaching strategies for teaching the Chinese language.
(2) Without using technology, I can prepare a lesson plan.
(3) Without using technology, I can address the common problems students have in learning the Chinese language (e.g., errors in pronunciation, Chinese characters, vocabulary, and grammar).
(4) Without using technology, I can promote meaningful discussion on the topics students are learning.

TCK

(1) I can use software (e.g., electronic dictionary, corpus, and Chinese learning app) designed specifically for Chinese language teaching or learning.
(2) I can use suitable technologies (e.g., PPT, flash animation, and electronic whiteboard) to present the content of the Chinese language.
(3) I can use suitable technologies to promote students' learning of Chinese language content.
(4) I can use some technologies (e.g., corpus and database) to conduct research on TCSL.
(5) I can use suitable technologies (e.g., PPT, flash animation, and electronic whiteboard) to present the differences between cultures.

TPK

(1)   I can use Internet search engines (e.g., Baidu, 360, Google) to prepare teaching materials.
(2)   I can choose suitable technologies to improve teaching approaches for a lesson.
(3)   I can teach Chinese language on online platforms (e.g., Zoom, Skype, Tencent Conference).
(4)   I can promote collaboration among my students by using technology (e.g., social media and online teaching platforms).
(5)   I can reflect on how to use technology for online teaching of the Chinese language.

TPACK

(1)   I can design student-centered activities that combine Chinese language content, pedagogy, and technology.
(2)   I can choose suitable technologies to promote my teaching and students' language skills.
(3)   I can conduct thematic teaching and promote students' online learning using suitable tools (e.g., WeChat, Tencent Conference).
(4)   I can design computer-assisted or web-based (e.g., blogs, Webquest) homework specifically for Chinese language learning.

Declarations

Conflicts of Interest The authors declare no conflict of interest.

Data Availability Statement Not applicable.

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