

EXPLORING PRESERVICE PRESCHOOL TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) AND ITS PREDICTING FACTORS

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Article history

Received date : 15-1-2026
Revised date : 16-1-2026
Accepted date : 17-2-2026
Published date : 3-3-2026

To cite this document:

Hou, Y., & Samsudin, M. A. (2026). Exploring preservice preschool teachers' technological pedagogical content knowledge (TPACK) and its predicting factors. *Journal of Islamic, Social, Economics and Development (JISED)*, 11 (81), 1 – 16.

Abstract: *With the rapid development of information technology, supporting and developing pre-service teachers' technology pedagogical content knowledge (TPACK) has become a top priority in higher education in China. This study investigated pre-service teachers' technological pedagogical content knowledge (TPACK) and the factors that influence it. This study collected data from pre-service teachers at three public universities in China using the Pre-service Teacher Technological Pedagogical Content Knowledge (PT-TPACK) survey, including seven domains: Technology Knowledge (TK), Pedagogical Knowledge (PK), Content Knowledge (CK), Technological Content Knowledge (TCK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technological Pedagogical Content Knowledge (TPACK). Descriptive statistics and SPSS data analysis were used for data analysis, with a significance level of 0.05. The results showed that the overall TPACK level of preservice preschool teachers was above average, and there are differences among various dimensions; There is no significant difference in TPACK levels among preschool teachers in terms of gender and grade; There are significant differences in terms of student origin and teaching internships.*

Keywords: *Technological Pedagogical Content Knowledge (TPACK); Preservice teachers; Teacher education; Preschool education*

Introduction

Information technology (IT) plays a key role in educational transformation and development (Kalyani, 2024). The promotion of information technology in the field of education has promoted teaching reform and helped teachers use technology to improve teaching quality. Meanwhile, information technology skills have become an important part of 21st-century skills (Liesa-Orús et al., 2020). In the context of education in China, the China Education Modernization Plan 2035 (Xinhua News Agency, 2019) proposes that one of the main development goals for 2035 is to build a modern education system that serves lifelong learning for all people and to popularize quality preschool education. In addition, the "Professional Competency Standards for Teachers of Preschool Education Majors (Trial)" (Ministry of Education of the People's Republic of China, 2021) requires preschool education majors to have information literacy and be able to master certain modern information technology knowledge.

Educational informatization has also become an important part of social informatization (Li et al., 2022). Most schools in China have strengthened their informatization construction, achieved Internet connection, and improved hardware and software related to information technology. The TPACK framework is an innovative direction for teacher development under the background of informatization and has become a trend in teacher education research and teacher knowledge structure (Wang et al., 2020). The use of the potential of information technology in teaching enriches and expands learning opportunities. It not only meets the needs of the "new generation of network" students, but also increases the effectiveness of the "learning" and "teaching" experience (Hsu, 2015). As the main force of the future preschool teacher team, the ability of pre-service preschool teachers to combine information technology with teaching practice has become a key ability of pre-service teachers (Chai et al., 2020).

However, teacher education in higher education shoulders the responsibility of training a new generation of teachers. However, in the current teacher education programs in higher education, the curriculum settings of Chinese pre-service teachers mostly focus on theoretical guidance or technical ability training, and neglect the training of pre-service teachers' practical ability to integrate information technology with teaching, resulting in pre-service teachers failing to make meaningful changes to the teaching process when applying information technology integrated teaching to simulation teaching and educational internships (Wang et al., 2020). Due to insufficient teaching experience, pre-service teachers lack the confidence to successfully integrate technology into teaching (Goktas et al., 2009). With the application of technology in teaching, the changes in the level of technology teaching content of pre-service teachers are worth studying. Based on this, under the TPACK framework, what is the real cognition of technological pedagogical content knowledge among Chinese preservice preschool teachers? This study investigated the status of TPACK for pre-service teachers at different levels and analyzed the characteristics of TPACK presented, intending to provide guidance for future preservice teacher training.

Literature Review

The TPACK Structure and Content

The TPACK model was introduced as a theoretical framework for understanding teachers' knowledge of integrating technology into teaching (Koehler & Mishra, 2009a). The TPACK framework can be used to conceptualize and measure the teacher's abilities and knowledge required to integrate technology into teaching (Graham et al., 2012). TPACK is a highly complex knowledge formed by the overlap of three basic knowledge: content knowledge (CK),

pedagogical knowledge (PK) and technological knowledge (TK). They are interrelated and produce four new knowledge areas: pedagogical content knowledge (PCK), technological content knowledge (TCK), technological pedagogical knowledge (TPK) and technological pedagogical content knowledge (TPACK). Therefore, the TPACK structure combination is shown in Figure 1. Therefore, the TPACK teacher knowledge framework was developed into a model containing 7 factors, which is described in detail as a complex interaction between the three knowledge systems (Koehler & Mishra, 2009b). The technology educational content knowledge (TPACK) framework is widely used to determine how teachers integrate technology into teaching methods.

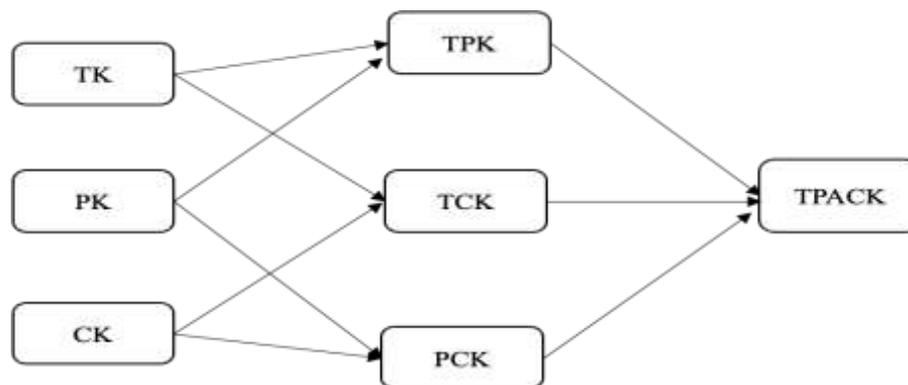


Figure 1 The TPACK Component Structure

TPACK provides a good framework for the knowledge system of pre-service teacher training (Wang et al., 2020b). In each dimension of technological pedagogical content knowledge (TPACK), the specific content of different disciplines is different. For pre-service preschool teachers, they need to receive teacher education and training to understand how to use technology to effectively improve teaching. The purpose of this is to enable pre-service teachers to master not only content knowledge and teaching knowledge, but also technical knowledge, and be able to apply this knowledge appropriately to teaching at the same time. Combined with the training of preschool majors in China's higher education, the specific description of each dimension of technological pedagogical content knowledge (TPACK), before they become formal teachers, can be summarized as follows:

- **CK** refers to the knowledge that educators use when teaching a specific subject area (Jüttner et al., 2013). For pre-service preschool teachers, their subject knowledge refers to the knowledge they need to master in the five major areas of preschool education: language, art, science, society, and health.
- **PK** refers to teachers' knowledge of various teaching practices, strategies and methods that promote student learning (Watzke, 2007). For pre-service preschool teachers, they need to master the knowledge related to the teaching process, methods and practices in the five major areas of preschool teaching: language, art, science, society and health, including the formulation of teaching plans, the selection of teaching methods, classroom management strategies, and the evaluation of student behavior and performance.
- **TK** refers to teachers' knowledge about traditional and new technologies that can be integrated into the curriculum (Zhang & Tang, 2021). Pre-service preschool teachers' understanding and application of existing technologies include understanding and being familiar with traditional technologies and modern information technologies (such as the

Internet, multimedia, information technology platforms, tools, products, and educational resources), as well as using information technology in educational settings.

- **TCK** refers to the knowledge about the interrelationship between technology and content (Zhang & Tang, 2021). Pre-service preschool teachers can use information technology to provide preschool children with learning experiences that are appropriate to their individual knowledge level, cognitive status, and learning preferences.
- **PCK** refers to the understanding of how specific topics, problems, or issues are organized, presented, and adapted to the different interests and abilities of learners, and how they are presented in instruction (Shulman, 1986). This means that pre-service preschool teachers have the knowledge needed to select teaching methods and strategies that are appropriate for teaching content in specific domains, and also include the ability to reconfigure and present teaching content to improve teaching outcomes.
- **TPK** refers to the knowledge of how educators use various technologies in teaching, and the understanding that the use of technology may change the way teachers teach (Schmidt et al., 2009). For pre-service preschool teachers, it is crucial to dynamically understand the mutual support, complementarity and constraints between technology and teaching methods, and to be able to design effective teaching strategies and activities to change the teaching process.
- **TPACK** refers to the knowledge required to integrate technology into preschool teaching. Teachers can intuitively understand the complex interactions between the three basic components of knowledge (CK, PK, TK) by using appropriate teaching methods and technologies to teach (Schmidt et al., 2009). This knowledge includes: the ability of pre-service preschool teachers to use technology to illustrate the teaching content in the preschool field; the ability to creatively use teaching skills to teach and design preschool activities; the ability to use technology to solve the challenges encountered by students in the learning activities, etc.

TPACK in the Context of Preschool Education

TPACK is a promising conceptual framework that reflects teachers' level of information-based teaching. A large number of studies on teacher TPACK assessment have been conducted mainly through questionnaires, interviews, classroom observations, and performance evaluations (Qiu et al., 2022). In China, many studies have applied the TPACK framework to the investigation and research of technology integration of preschool teachers (including pre-service teachers and in-service teachers). For example, the results of Liang et al., (2013) on preschool teachers in Taiwan showed that most preschool teachers had a strong understanding of the PK and PCK dimensions, but some teachers lacked confidence in their TK. Luo et al. (2023) conducted a large-scale survey of preschool teachers and verified the applicability of the scale used and the TPACK knowledge domain in early childhood education. (Luo et al., 2021) explored the positive attitudes of pre-service teachers towards digital technology when participating in field teaching experiences. Miao (2023) explored how to use the TPACK model to cultivate the information-based teaching skills of preschool education normal students. Zhong & Nair (2022) used an online questionnaire to investigate the TPACK and related factors of preschool trainees. The results showed that the application of CK and PK by interns was significantly positively correlated with the application of TPACK. The trainees' ability to apply TPACK needs to be further improved.

A large number of studies have focused on TPACK for preschool teachers (including in-service and pre-service teachers). Studies have shown that preschool teachers have a positive perception of TPACK, and their overall level is above average, but they lack technical

knowledge (Liang et al., 2013; Ye & Qiu, 2019; Zhu, 2014). However, most studies on TPACK for pre-service teachers remain at a shallow level of status survey and training model. Previous studies did not fully emphasize ECE characteristics; nor did they clearly indicate the factors that affect the TPACK level of preschool teachers; the TPACK item scale used did not clearly describe the relevant fields; and there were few studies evaluating the TPACK of pre-service teachers in preschool education.

Based on the literature review, the purpose of this study is threefold: to explore the level of TPACK among pre-service preschool teachers; the relationship between the various elements of TPACK; and to understand the factors that affect the level of TPACK among pre-service preschool teachers. This is intended to provide further efforts for higher education institutions and teaching improvements to develop TPACK among preservice teachers. Based on the main objectives of the study, the research questions are:

1. What is the level of TPACK development of pre-service preschool teachers?
2. What are the characteristics of TPACK knowledge development of pre-service preschool teachers?
3. What are the factors that affect the TPACK level of pre-service preschool teachers?

Methods

Participants

The participants of this study are undergraduate and master students who have participated in educational internships at three public colleges in H Province, China, namely, pre-service preschool teachers. It is worth noting that all participants had completed Computer Fundamentals, Educational Technology, Modern Educational Technology and its Applications, and Microteaching Courses, which are required courses for pre-service teachers who have certain teaching techniques and skills. The pre-service teachers who participated in this survey had no experience in online teaching, but most of them had participated in professional internships and preparatory courses related to technology integration. The length of each person's internship was different. More detailed information about their demographic information can be found in **Error! Reference source not found..** This survey is mainly conducted voluntarily by students, using electronic questionnaires filled out online for data collection. A total of 361 questionnaires were collected, and after sorting and removing them, 346 valid questionnaires were obtained, with an effective response rate of 95.8%.

Table 1 Description of Research Subjects

Item	Index	N	%
Gender	Male	40	11.56
	Female	306	88.44
Education background	Bachelor	287	82.95
Total Edges	Master	59	17.5
Region	Town	124	35.84
	village	222	64.16
Teaching experience	1 month	81	23.41
	2-3 months	108	31.21
	4-6 months	131	37.86
	7-12 months	15	4.34
	Over 12 months	11	3.18
Total		346	100%

Instrument

The PT-TPACK survey used in this study adopted the scale validated by Pamuk et al. (2015). The scale is divided into two parts. The first part consists of demographic information of the respondents, including gender, age, grade, and educational internship situation; The second part involves 37 items related to the TPACK framework. Specifically, the second part is the PT-TPACK survey for pre-service teachers, which has 7 dimensions and a total of 37 items. The dimensions and items correspond to TK (4), CK (8), PK (4), PCK (6), TCK (4), TPK (4), and TPACK (7). This survey uses the Likert five-point test scale, with scores set at 1-5 for each item, ranging from strongly disagree to strongly agree (1-strongly disagree; 2-somewhat disagree/disagree; 3-agree; 4-somewhat agree; 5-strongly agree).

Data Analysis

This study collected data through an online questionnaire in the second semester of the 2024-2025 academic year. With the help of relevant preschool teachers from the three universities, the questionnaire was sent to the class WeChat group. The questionnaire responses were anonymous, and participants were assured that there was no right or wrong answer. Since the participants were adults, they had their own choices and followed the voluntary filling.

This study used SPSS (Social Science Statistics Software Package) 30.0 for statistical analysis to test the internal consistency of the PT-TPACK survey. First, the data collected online were entered and coded to test the discrimination and rationality of each item in the scale; Then conduct exploratory factor analysis to further test the structural validity of the questionnaire. Reliability is a statistical method used to test the consistency, stability, and reliability of quantitative data results. The reliability test results can measure the true reliability of the measurement results. The reliability coefficient is between 0-1, and the larger the reliability coefficient, the more consistent, reliable, and stable the measurement results are. Validity refers to the degree of effectiveness of a test, mainly to check whether the measuring tool can measure the expected thing to be measured.

Regarding the research question, correlation analysis was used to show that there is a correlation between TK, PK, CK, TPK, TCK, PCK and TPACK. Pearson correlation coefficient was used to study the degree of correlation between variables and whether the correlation was significant or not. A variance analysis of in pre-service preschool teachers' TPACK levels on demographic variables was also conducted.

Results

This section consists of four parts: reliability and validity test of PT-TPACK, pre-service preschool teachers' perceptions of the TPACK, correlation analyses between the elements of the TPACK, and variance analysis in TPACK levels among preschool teachers on demographic variables.

Reliability and Validity Testing

Reliability test using Cronbach's alpha coefficients from reliability analyses were conducted for each of the seven subscales and the overall scale. It is generally believed that a reliability coefficient higher than 0.8 indicates high reliability; The reliability coefficient ranges from 0.7 to 0.8, indicating good reliability; Between 0.6 and 0.7, indicating acceptable reliability; If the reliability coefficient is less than 0.6, it indicates poor reliability and requires consideration of rewriting the questionnaire. According to the data analysis using SPSS 29.0 statistical software, the internal consistency alpha coefficient of the total scale is 0.984, and the alpha coefficients

of the other dimensions are distributed between 0.831 and 0.962. The details are shown in **Error! Reference source not found.** Overall, the questionnaire has good internal consistency.

Table 2 Cronbach's A Coefficient of PT-TPACK Factors

Subscales	N	Cronbach'S	Significance of Bartlett's Sphericity Test
Technology Knowledge (TK)	4	0.831	0.000
Content Knowledge (CK)	8	0.950	0.000
Pedagogical Knowledge (PK)	4	0.936	0.000
Pedagogical Content Knowledge (PCK)	6	0.957	0.000
Technological Pedagogical Knowledge (TPK)	4	0.922	0.000
Technological Content Knowledge (TCK)	4	0.930	0.000
Technological Pedagogical Content Knowledge (TPACK)	7	0.962	0.000
All Subscales	37	0.984	0.000

The validity test was conducted using factor analysis for KMO and Bartlett sphericity tests. If the KMO value is closer to 1, it indicates that the variables are more correlated and more suitable for factor analysis. It is generally believed that a KMO value higher than 0.7 is suitable for factor analysis, and a KMO value between 0.6 and 0.7 is acceptable. If a KMO value lower than 0.6 cannot be used for factor analysis, further modifications to the measurement table are needed. The significance of Bartlett's sphericity test < 0.05 indicates that the data is distributed in a spherical shape, and the boundaries between each variable are relatively clear. The validity of the total table and 7 sub-dimensions was tested, and the results showed that the KMO value of the total table was 0.970, the Sig. value of the questionnaire was 0.000, and the significance of the Bartlett sphericity test was less than 0.05. The KMO values of all dimensions were above 0.7, and the significance of the Bartlett sphericity test was less than 0.05, reaching a significant level. This indicates that there are common factors between the total table and each subdimension, and the structural validity is good, and suitable for factor analysis. Overall, the PT-TPACK scale is effective and reliable for the selected sample of preservice preschool teachers in China.

Pre-service Preschool Teachers' Perception of TPACK

According to **Error! Reference source not found.**, the average overall score of PT-TPACK for preschool teachers is 3.332, indicating that the overall development of TPACK is at a moderate level. The mean range of the seven dimensions is between 3 and 4, and the ranking of the mean from high to low is technological content knowledge (TCK), pedagogical knowledge (PK), technological pedagogical content knowledge (TPACK), pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), content knowledge (CK), and technological knowledge (TK). Among the knowledge dimensions related to the T element, the TCK score is the highest at 3.387, indicating that prospective preschool teachers can use technology in their teaching content. Among the knowledge dimensions unrelated to the T element, the CK score is the lowest at 3.27, indicating that prospective preschool teachers have relatively insufficient knowledge reserves in the five major areas of content knowledge in preschool education. The reason for this may be that the cultural and skill courses in preschool education involve a lot of content, especially the teaching methods knowledge in the five major

fields of preschool education that are mutually integrated and require normal students to spend enough time learning to master.

Table 3 Basic Information of PT-TPACK Dimensions for Preschool Teachers

Subscales	N	Minimum	Maximum	M	SD
Technology Knowledge (TK)	346	1.00	5.00	3.225	2.739
Content Knowledge (CK)	346	1.00	5.00	3.270	5.641
Pedagogical Knowledge (PK)	346	1.00	5.00	3.355	3.000
Pedagogical Content Knowledge (PCK)	346	1.00	5.00	3.373	4.348
Technological Pedagogical Knowledge (TPK)	346	1.00	5.00	3.34	2.764
Technological Content Knowledge (TCK)	346	2.00	5.00	3.387	2.907
Technological Pedagogical Content Knowledge (TPACK)	346	1.00	5.00	3.382	4.861
All Subscales	346	1.00	5.00	3.332	23.608

Correlation Analysis of PT-TPACK Dimensions among Pre-service Teachers

The Pearson correlation coefficient is used to study the degree of correlation between two variables, analyze whether there is a correlation between the two variables and whether the correlation is significant. Generally speaking, if the correlation coefficient is greater than 0, two variables are positively correlated; The correlation coefficient is less than 0, and the two variables are negatively correlated. Cohen Jacob once proposed to determine the strength of correlation based on the magnitude of the correlation coefficient values. It is generally believed that if the correlation coefficient value is between 0.10 and 0.30, it is considered to have a weak correlation; Between 0.30 and 0.50, there is a moderate correlation; Between 0.50 and 0.70, it can be considered as having a strong correlation; A correlation greater than 0.7 is extremely strong. This study analyzed the TPACK dimensions of pre-service teachers using Pearson correlation coefficients, and the analysis results are shown in Table 4.

Table 4 Pearson Correlation Coefficients of TPACK

Subscales	TK	CK	PK	PCK	TPK	TCK	TRACK
TK	1						
CK	0.699**	1					
PK	0.617**	0.797**	1				
TCK	0.454**	0.579**	0.519**	1			
TPK	0.631**	0.789**	0.769**	0.628**	1		
PCK	0.611**	0.789**	0.871**	0.570**	0.836**	1	
TRACK	0.649**	0.796**	0.797**	0.652**	0.879**	0.843**	1

Note: ** indicates a significant correlation at 0.01 level (bilateral), and * indicates a significant correlation at 0.05 level (bilateral).

From Table 4, it can be seen that the correlation coefficients between TK, CK, PK, TCK, TPK, PCK and TPACK of preservice teachers are 0.649**, 0.796**, 0.797**, 0.652**, 0.879**, 0.843**, all greater than 0.5, indicating a strong correlation between TK, CK, PK, PCK, TPK, TCK and TPACK of pre-service teachers. In addition, the correlation coefficient between TPACK and various dimensions of preservice teachers is ranked from high to low as TPK > PCK > PK > CK > TCK > TK. It can be seen that TPK, PCK, and TPACK are most correlated, followed by PK. CK is highly correlated with TPACK, while TCK and TK are

least correlated with TPACK. From this, it can be seen that improving TPK is an effective way to enhance their TPCK level, and TPK and PCK are important breakthroughs for preservice teachers to efficiently improve their TPCK level at present.

Variance Analysis in TPACK among Pre-service Teachers on Demographic Variables

This section mainly starts with the gender, place of origin, grade, and teaching experience of the surveyed preschool teachers, and uses the independent sample T-test method and one-way ANOVA to explore the differences in demographic variables that affect the TPACK level of preschool teachers.

Comparison of Gender

In the collected questionnaire data, the ratio of male to female students is approximately 1:8. From the average values of various dimensions (see **Error! Reference source not found.**), there is not much difference in the mean between males and females. According to the results of one-way ANOVA on different factors of gender, the probability P-values corresponding to the observed values of the F statistics obtained from the TK, CK, PK, PCK, TPK, TCK, TPACK and total table were all greater than 0. If the significance level α is 0.05, due to the P-value being greater than the significance level α , the null hypothesis should not be rejected, and it should be assumed that gender has no significant impact on the factors in the scale, that is, there is no significant difference in the TPACK status of preschool education teachers of different genders. In previous surveys of pre-service teachers, it was found that male pre-service teachers scored significantly higher than female teachers in knowledge related to information technology. It is generally believed that boys have a stronger ability to operate information technology, but this result was not found in the author's survey. There are two reasons for this result. Firstly, there is a significant difference in the proportion of gender differences among preschool education teacher students, with more females than males, resulting in a disproportionate sample size; On the other hand, due to the particularity of preschool education, compared to female, male need to invest more time in skill courses during the process of receiving teacher education. Therefore, compared to females, there was no significant difference observed.



Figure 2 Average Values of TPACK Dimensions in Gender

Comparison of Regional Differences

To understand the differences in TPACK among pre-service teachers in their regional, this study conducted a one-way analysis of variance (ANOVA). The research results indicate that the P-values of preservice teachers in the TK, CK, PK, PCK, TPK, TCK, and TPACK dimensions are all greater than 0.05, indicating that there is no significant difference in TPACK among preschool teachers from different source areas. In addition, based on the average of the surveyed students from their hometowns (See Figure 3), the average of students from urban areas is slightly higher than that from rural areas. Mainly because the economic foundation of urban student families is relatively good, they have more advantages in accessing information and communication technology.

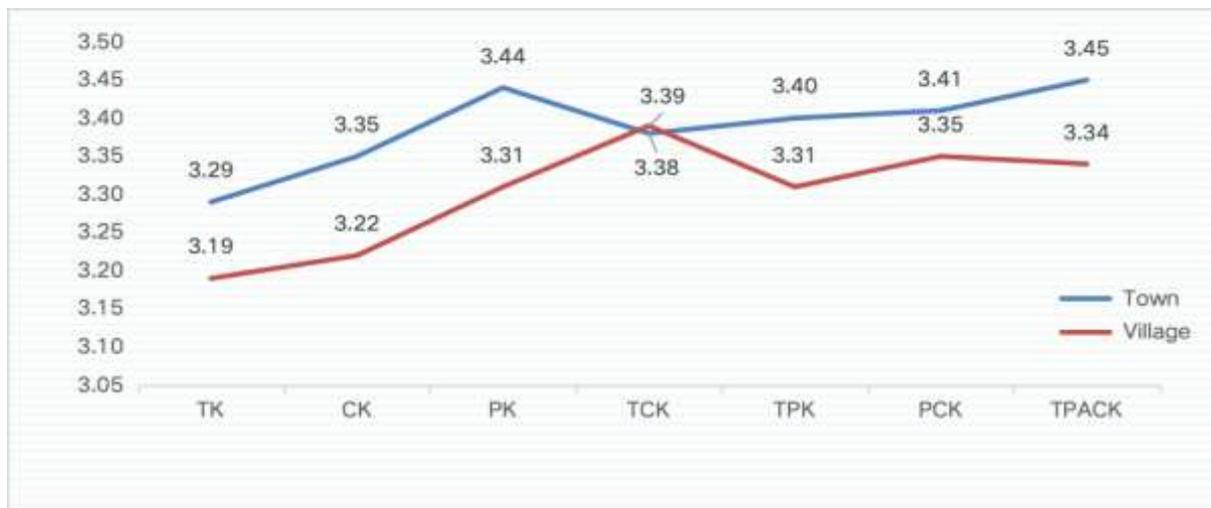


Figure 3 Average Values of TPACK Dimensions in Regional

Comparison of Grade Differences

Based on the one-way ANOVA method, the impact of grade on TPACK of preschool teachers was discussed from seven dimensions, and the results are shown in Table 5. From the results, it can be seen that from various dimensions, the level of performance of preschool teachers in the fourth year of undergraduate education and graduate education is equivalent in all aspects. Significance $P > 0.05$, which means that there is no significant effect on grade. This reason may be because the samples are all from the same province, and there is little difference in education policies and training methods.

Table 5 ANOVA Test of Pre-service Teacher Grades in Seven Dimensions

Subscales	Grade	Mean	F	Sig.
TK	Bachelor	3.24	0.987	0.321
	Master	3.14		
PK	Bachelor	3.33	1.820	0.178
	Master	3.47		
CK	Bachelor	3.27	0.000	0.996
	Master	3.27		
PCK	Bachelor	3.33	4.885	0.028
	Master	3.56		
TPK	Bachelor	3.33	0.058	0.809
	Master	3.36		
TCK	Bachelor	3.36	3.655	0.057

TPACK	Master	3.51	2.006	0.158
	Bachelor	3.56		
	Master	3.50		

Comparison of Teaching Internship

The research subjects of this study have all participated in educational internships. In this study, the internship time of pre-service teachers was divided into five stages: 1 month, 2-3 months, 4-6 months, 6-12 months, and more than 12 months. The results of one-way ANOVA showed that the significance values of TK, CK, PK, PCK, TPK, TCK, and TPACK dimensions were 0.001, 0.000, 0.001, 0.002, 0.003, 0.005, and 0.005, respectively. The estimated values of all parameters were significant at the $p < 0.05$ level. In terms of difference testing, there is a significant difference in the overall level of TPACK among pre-service teachers with different lengths of teaching internships. Further multiple comparisons revealed that in the TK, TPK, TCK, and TPACK dimensions, pre-service teachers with longer internship periods had significantly higher levels than those with shorter internship periods. This indicates that pre-service teachers with longer internship hours have a relatively better grasp of technological pedagogical content knowledge.

Table 6 ANOVA Test of Pre-service Teachers' Internship Time in Seven Dimensions

Subscales	Mean					F	Sig.
	1 month N=81	2-3 months N=108	4-6 months N=131	7-12 months N=15	Over 12 months N=11		
TK	3.10	3.11	3.37	3.12	3.66	4.383	.002
CK	3.03	3.17	3.43	3.39	3.93	7.681	<.001
PK	3.11	3.31	3.51	3.45	3.59	4.094	.003
PCK	3.18	3.30	3.56	3.21	3.56	4.344	.002
TPK	3.16	3.22	3.51	3.48	3.59	4.989	<.003
TCK	3.23	3.33	3.50	3.48	3.67	4.509	.001
TRACK	3.18	3.32	3.52	3.47	3.78	4.211	.002

Discussion and Conclusion

TPACK represents the ability of teachers to design appropriate teaching plans and implement effective teaching based on specific teaching situations, taking into account subject knowledge, pedagogical knowledge, technological knowledge, etc. This study continues the tradition of TPACK research and aims to better understand the development of TPACK among pre-service teachers in early childhood education. In this study, pre-service teachers have a positive perception of TPACK, and their overall level of TPACK is good, but there is still a large scope for improvement. Compared to the information technology knowledge of teachers, pre-service teachers have a relatively better grasp of pedagogical knowledge (PK), which is closely related to the cultivation of normal students. Regarding several types of knowledge related to information technology, the scores of pre-service teachers are not high, which may be related to the current lack of widespread and in-depth education on information technology in pre-service training.

In addition, pre-service teachers are a special group who have a dual identity as both future teachers and students. Most of the teaching skills they learn in school are prepared for future teaching, and they also need effective guidance from teachers to make technology support teaching. However, in the field of preschool education, what are the advantages and

disadvantages of information technology in teaching? Should young children be exposed to IT too early? How much role can information technology play? The discussion on these issues is still controversial, which is the reason why the level of information technology application by pre-service teachers in preschool education still needs to be improved.

When studying the internal correlation of TPACK, the research results found a significant positive correlation between TPACK components. This finding is consistent with previous TPACK studies (Chai et al., 2013; Yang et al., 2021; Scherer et al., 2017), indicating that Chinese preservice preschool teachers can support each other in different knowledge areas under TPACK.

The results indicate that there is no significant in TPACK among preschool teachers of gender. This is consistent with the research findings of Ye & Qiu (2019), which pointed out that there is no difference in the TPACK status of preschool education students based on gender. The TPACK for pre-service teachers whose place of origin is a town is slightly higher than that of a countryside. There is no significant overall difference in TPACK between fourth-year undergraduates and postgraduates. Pre-service teachers with longer internship periods are better at mastering information technology and more easily integrate it into education. On the positive side, their technical teaching experience almost comes from classroom observation and educational internships, which provide ample opportunities for the development of TPACK for pre-service teachers. TPACK is an important branch of professional development for Chinese teachers in the new era. How to develop preservice teachers' TPACK through effective models requires continuous research and practice by researchers and educators.

The participants of this study are pre-service preschool teachers, so the research results have direct guiding significance for the cultivation of educational and teaching skills and classroom technology integration of this group. For pre-service teachers, it is necessary to actively think about the relationship between pedagogy, content, and technology (Wang, 2020), and to improve the integration of information technology in order to have a high level of TPACK.

Furthermore, for the continuing education of in-service teachers, it is important to combine teaching practice with reflection. The American psychologist Posner (2009) proposed a teacher growth formula (teacher's profession = experience + reflection), which reflects the objective law of teacher professional development. Therefore, in-service teachers can develop TPACK from two aspects: first, recognize the situation of China's educational informatization development, improve awareness and initiative of classroom technology integration, and accumulate experience in the teaching process. Second, in the process of teacher TPACK development, conduct teaching seminars around common themes, attach importance to teaching reflection, and realize the dynamic development of TPACK in communication, thinking and collaboration.

For educational researchers, conducting multidimensional studies from multiple subject fields and validating research findings on teachers' TPACK development is not only a requirement for the intrinsic validity of the findings but also a necessity for the current national and international trends in TPACK research.

Methods Contributions, Limitations, and Impacts

Based on the evidence collected in this study, it is helpful to explore the TPACK level of pre-service teachers. The TPACK survey is a tool with high reliability and validity that can be used

to measure the TPACK level of pre-service teachers in China. By using this validated scale, it was determined that the TPACK of Chinese pre-service preschool teachers was at a moderate level. This shows that it is crucial to improve the TPACK skills of future teachers through higher education support and improvement of information technology. The strengths of this study not only found that the elements of the TPACK dimension are interrelated, but also explored the factors that may affect the development of TPACK in pre-service teachers. The results and implications of this study can provide some inspiration for future higher education on teacher training.

This study also has some limitations. First, only the self-reported TPACK survey was validated, and further research is needed on the test-retest reliability and concurrent validity of the revised TPACK survey in the preschool education setting. Second, the gender ratio in the sample may affect the robustness of the correlation analysis of the relationship between gender and TPACK. Third, in future studies, in addition to personal characteristics, contextual factors such as environment, resources, and technical support should also be considered. Fourth, the data collection for this study was only from one province, and each province has different higher education policies and teacher training models. This result may not be applicable to pre-service teachers in other provinces. Therefore, future research can invite different universities to participate, repeat similar studies, and explore other issues that have not been discussed. This is to obtain more data and thus provide more comprehensive insights.

Acknowledgements

I would like to express our sincere gratitude to my supervisor, Professor Mohd Ali Samsudin, for his invaluable guidance and unwavering support throughout the research process. His timely feedback and patient mentorship were invaluable in shaping my research and helping me to overcome challenges.

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