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Investigating Technological Pedagogical Content Knowledge Competencies among Trainee Teachers in the Context of ICT Course

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The Technological Pedagogical Content Knowledge (TPACK) framework developed over a decade ago is still valid and applicable in educational contexts when dealing with the use of technology in teaching and learning. With widespread availability of devices and prolific use of technology among students, teachers need to be conversant with various technologies that can be integrated and enhance the teaching and learning process. Most teacher education programmes equip trainee teachers with the integration of technology in the lessons and introduce them to instructional design that would align to the curriculum and make their teaching attractive and effective. It is important to establish the level of TPACK among trainee teachers and prepare them appropriately with necessary domain of knowledge to enable them to function well in future classrooms. This study was conducted with trainee teachers to determine the validity and reliability of the TPACK questionnaire and to identify trainee teachers' perceived pathways to TPACK. Data were analysed using the maximum likelihood estimation (MLE) procedure, and the measurement model was assessed using confirmatory factor analysis (CFA). The structural model was developed and the path coefficients and their statistical significance were tested to determine the correlations between TPACK competencies.

Le modèle TPACK portant sur les connaissances technologiques, pédagogiques et de contenu, développé il y a plus de dix ans, demeure valide et applicable dans les contextes pédagogiques où l'enseignement et l'apprentissage sont appuyés par la technologie. La grande disponibilité des appareils technologiques et leur emploi généralisé par les élèves exigent que les enseignants soient à l'aise avec les technologies qui peuvent être intégrées pour améliorer l'enseignement et l'apprentissage. La plupart des programmes de formation des enseignants les prépare à intégrer la technologie dans leurs leçons et en aligner la conception pédagogique avec les programmes d'études pour augmenter l'efficacité de leur enseignement. Il est important d'établir le niveau de TPACK chez les enseignants stagiaires et de les préparer en conséquence en leur communiquant les connaissances nécessaires pour bien fonctionner dans les salles de classe de l'avenir. Cette étude s'est déroulée auprès d'enseignants stagiaires, de sorte à déterminer la validité et la fiabilité du questionnaire TPACK et pour identifier ce que les enseignants stagiaires perçoivent comme étant les moyens d'acquérir les connaissances liées au TPACK. Les données ont été analysées par la méthode d'estimation du maximum de vraisemblance et le modèle de mesure a été évalué par une analyse factorielle confirmatoire. Le modèle structurel a été élaboré, et les chemins et la signification statistique des coefficients ont été testés, de sorte à établir les corrélations entre les compétences du modèle TPACK.

The Technological Pedagogical Content Knowledge (TPACK) framework identifies the knowledge that teachers need to teach effectively with technology. Shulman (1987) proposed that teachers not only need content knowledge, but they also need pedagogical knowledge to teach effectively. He urged that knowledge about content and pedagogy are interconnected, which lead to the proposal of the idea of Pedagogical Content Knowledge. As technological tools are becoming prevalent amongst the general population, teachers use various devices to enhance instruction in their classrooms. This requires teachers to be equipped with the technological knowledge of how such devices function. Mishra and Koehler (2006) extended the Pedagogical Content Knowledge with technological knowledge as an extended framework. They proposed that to effectively integrate technology in classrooms, teachers must be conversant with the relationships between technology and content and how technology can be used to support the learning process of specific content. At the core of this framework is the interplay of three domains of knowledge: Content Knowledge (CK), Pedagogical Knowledge (PK), and Technology Knowledge (TK), each of which are explained within the literature (Koehler and Mishra, 2009; Mishra and Koehler, 2006). The condensed interpretations of the knowledge types are:

- *Content Knowledge* (CK), which refers to expert knowledge of subject matter content such as language, mathematics, or science.
- *Pedagogical Knowledge* (PK), which indicates knowledge of how best one can deliver a lesson to meet the learning goals, strategies, and lesson design. For instance, a teacher who teaches language will use different pedagogy than a science teacher.
- *Technology Knowledge* (TK), which is concerned with the fluency of how each technology functions and understanding its affordances.

The complex interaction between CK, PK, and TK resulted in three other types of knowledge: Pedagogical Content Knowledge (PCK), Technological Content Knowledge (TCK), and Technological Pedagogical Knowledge (TPK). The framework known as Technological Pedagogical Content Knowledge (TPACK) was developed through the interactions between and among these types of knowledge (Koehler and Mishra, 2009). Our study translated the TPACK questionnaire into Arabic and validated the questionnaire for use with trainee teachers. We also examined trainee teachers' perceived pathways to TPACK.

Review of the Literature

In preparing teachers for 21st century schools, training institutions around the world are fully cognisant of the need to equip trainees not only with disciplinary knowledge and teaching skills, but also with strategies to effectively deliver the content using technology. While ranges of technologies are readily available, teaching how to integrate technology has been a challenge for teacher educators. Many other authors advocate instilling TPACK among pre-service teachers to enable them to function as competent teachers in techno-centric classrooms.

Numerous studies have been conducted about pre-service teachers' TPACK in the last few decades (Gungoren & Horzum, 2015; Khine, 2015; Voogt, Fisser, Pareja Roblin, Tondeur, & van Braak, 2013). The TPACK questionnaire has been used to gauge the level of teachers' knowledge, to diagnose deficiencies in teachers' knowledge in various domains, to investigate the profiles and characteristics of teachers, and to observe the changes in teachers' beliefs and attitudes toward technology. Gur and Karamete (2015) reported that analyses of 116 studies published between 2011 and 2014 in scholarly journals related to the theme of ICT and TPACK. The studies presented findings from various points of views related to ICT integration and the use of TPACK as a framework. Among the findings are the acceptance of new technology among teachers, building self-confidence in technology use, outcomes of intervention procedures, identifying gaps in where technology is used in the classroom, and suggestions to overcome difficulties in integrating technology.

According to Admiraal et al. (2017) the success of how technology is taught in teacher education programmes is dependent upon how student teachers apply technology in schools when they become teachers. The work of Admiraal and colleagues evaluated two technology-infused courses in a teacher education programme that prepare pre-service teachers to integrate technology into K-12 instruction. The study utilised questionnaires, assignments, instructional materials, and interviews to examine how technology infusion was implemented and evaluated by student teachers. The study also investigated how technology infusion was enacted by student teachers in class, as well as how their technology use was evaluated. The two technology-infused courses on teaching and learning confirmed the importance of teaching practice in developing pre-service teachers' knowledge and skills in this area. Admiraal and collaborators reported that the importance of teaching practice to develop pre-service teachers' integrating technology in instruction is like the finding on the development of TPACK as reported by other researchers (Kaufman, 2014; Messina & Tabone, 2015; Tondeur, Pareja Roblin, van Braak, Voogt, & Prestridge, 2016). Additionally, the evaluation of two courses revealed the importance of teaching in authentic classroom settings. Finally, the study found that both colleagues in school and teacher educators acting as role models seemed to be an important motivator for integration of technology in the classroom.

Agyei and Voogt (2015) explored the impact of strategies applied in a mathematics instructional technology course for developing technology integration competencies with 105 pre-service teachers. The study utilized a TPACK lesson plan rubric, an observation rubric, lesson plans, and lesson observations to assess technology integration competencies. The results indicated that pre-service teachers' level of technology integration competencies was increased after participation in the course.

Using pre- and post-test design, Horzum (2013) investigated technological pedagogical content knowledge of 239 pre-service teachers who were studying instructional technology material development course with the use of TPACK scales and Study Process Questionnaire (SPQ). While TPACK scales measure the level of various knowledge domains, SPQ measures the deep and surface levels of learning approaches. The study explored the difference in TPACK domains before and after attending the course. The study found that among the pre-service teachers, 69 preferred the surface learning approach, 97 preferred the deep learning approach, and the remaining preferred both deep and surface approaches. The study also illustrated that pre-service teachers who have a deep learning approach and surface and deep learning approaches have higher TK, TCK, TPK, and TPACK scores than pre-service teachers who have a surface learning approach.

In another study, Phillips (2016) reported findings from an eight-month-long case study on the use of and non-use of digital technologies among teachers in an Australian secondary school. The study employed ethnographic observations and semi-structured interviews with the participants as well as their key professional learning colleagues. The participants in the study had between four and 12 years of mathematics and physics teaching experience in a co-educational government school. The researcher showed a participant, Anna, a diagram of TPACK framework and explained the different components. She was then asked to indicate where she perceived her knowledge would be best located in the diagram. When two of her professional learning colleagues were asked about Anna's TPACK, they had different perspectives about Anna's knowledge. The author suggested that TPACK may be judged from a communal perspective as well as from an individual's perspective. The author noted that TPACK indicates knowledge used to support current practices and knowledge in making, empathizing TPACK development is an ongoing process.

In an ethnographic case study, Saudelli and Ciampa (2016) used technological pedagogical content knowledge (TPACK) as a theoretical lens to examine whether and how the three knowledge components that form the foundation of the TPACK framework—TK, PK and CK—have similar levels of influence on teachers' language arts teaching practices. The study also analysed how each teacher incorporated iPad technologically-enhanced pedagogical practices, and made connections to their beliefs about the role of technology and education. In this case study, data were collected from classroom observation field notes, teacher interviews, and teacher blogs. The study found that teachers' beliefs about mobile technology integration influenced their decisions and teaching practices. The authors noted that TPACK framework is a useful tool to understand teachers' self-efficacy beliefs. Also, it can provide professional development activities in technology integration and overcome barriers.

Technology proficiency, TPACK, and beliefs about technology among pre-service teacher training was explored by Messina and Tabone (2015) with the use of a self-administered questionnaire. The study involved 79 trainees in a teacher education programme; the study found that the trainee teachers have low technology proficiency and difficulty in integrating technology, pedagogy, and disciplinary content. The study also found that teacher trainers themselves lack modelling to use such technology. The authors suggested the need to develop technology integration among both trainees and faculty.

Xiang and Ning (2014) reported a study that investigated the profile of Chinese pre-service mathematics teachers' TPACK with 106 students. The results showed that pre-service mathematics teachers rated themselves as most competent in content knowledge and least competent in TPACK. The results also showed that the scores for technology related factors are generally lower than non-technology related factors. This implies that pre-service teachers are more familiar with traditional way of teaching mathematics. The authors suggested that to obtain more complete data, qualitative methods such as classroom observation and in-depth interviews on teachers' beliefs, knowledge, and practice are needed. The above-mentioned studies highlighted the importance of TPACK among pre-service and in-service teachers as well as the need for sufficient knowledge in all domains in order to function well in technology enhanced learning environments.

A qualitative study of pre-service primary school teachers' TPACK development over their training period was conducted by Gill and Dalgarno (2017). The study involved six pre-service teachers who were enrolled in the four-year initial teacher education programme in an Australian university. Interviews were conducted in six phases over four years; each phase focused on the pre-service teachers' developmental progress and intent to use ICTs in teaching. The interviews were later transcribed and analysed with qualitative software. The authors reported that the results provided a clear indication of TK, TCK, TPK, and TPACK development by the participants. The study described year-by-year development in each of the domains. This longitudinal investigation provided clear insight into how pre-service teachers gradually developed TPACK during their course of study.

While investigating TPACK in teacher education and preparing teachers to use technology, Voogt and McKenney (2017) emphasized that scant attention is currently given to teachers needing to foster early literacy using technology. Their study examined how five teacher education institutes in the Netherlands are developing technological pedagogical content knowledge among trainee teachers in order to effectively use technology for early literacy. A total of 12 teacher educators were selected for focus group interviews based on their expertise in early literacy and their responsibility for including technology in the curriculum. A series of 60-90 minute interviews were conducted with the teacher educators, with questions relating to knowledge about software and hardware, knowledge about effective characteristics of technology, and knowledge about effective use of technology that is essential for early literacy developments. The results from the data analysis found that teacher education institutes are not spending enough time on teaching about technology. Some of the educators were not even aware about software applications that could add value to the early literacy of their students. The authors suggested that collaboration between teacher educators of technology and early literacy is necessary to close the gap.

Research Context and Participants

This study was conducted in a teacher training institute in a Persian Gulf nation-state which offers four-year undergraduate teacher education program (Bachelor of Education). The program aims to produce high calibre teachers with innovative teaching methods who use technology extensively. In the program, students are required to take a course on Information and Communication Technology (ICT). The course introduces a variety of technologies available to use in the classroom and how such technologies can be used to enhance teaching. TPACK has been studied extensively in many educational contexts; however, few studies have been conducted in the Gulf countries (i.e., Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates). The TPACK questionnaire was originally developed by Mishra and Koehler (2006) in English; this study used an Arabic language translation of the questionnaire with pre-service teachers for the first time. This self-reporting quantitative survey questionnaire comprises 36 Likert-type items assessing six components. These components are Technology Knowledge (TK), Content Knowledge (CK), Pedagogical Knowledge (PK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK), and Technology Pedagogical Content Knowledge (TPACK).

The TPACK survey was administered to third year students who agreed to participate voluntarily in the study. Sixty-three female students completed the questionnaire while they were enrolled in the Information and Communication Technology in Education class. The duration of the course was 15 weeks. During the course of study, students were introduced to concepts and contemporary learning theories related to digital learning, evaluated a range of technologies commonly used to support digital learning and assessment, and designed an exemplar lesson plan to support digital learning. The participants' ages ranged from 21 to 25 years. The participants had no formal teaching experience except for their practicum component where they had spent six weeks in schools for observation.

Although the sample size for the study is relatively small (N = 63) we justify this based on our choice of model complexity. As Bentler and Chou (1987) argued, issues of sample size depend on model complexity; the recommended estimated ratio between sample size and number of parameters is 5 to 1. In this study, the ratio was 10 to 1. Sample sizes equivalent to that reported in this study have been analyzed in similar ways as Ferguson, James, O'Hehir, & Sanders (2003); Martocchio and Judge (1997); and Silvester, Patterson, Koczwara, and Ferguson (2007) have shown.

Research Questions

Given the preceding review, the research questions this study attempted to answer were:

1. How can we examine the validity and reliability of the translated version of TPACK in this context?
2. What are the pre-service teachers' perceived pathways to TPACK?

Data Analysis

Descriptive Statistics

The data was analysed to find out the mean scores, standard deviation, and average variance extracted for each of the items in every construct. The composite reliability of the constructs was also established.

Structural Equation Modelling

Structural equation modelling (SEM) was used to analyse the data. SEM is a collection of statistical methods for modelling the multivariate relationship between variables. It is also a flexible and powerful technique for examining various hypothesized relationships (In'nami & Koizumi, 2013). SEM was used in our analysis because this method measures latent traits. According to Teo (2009), unlike traditional regression technique, SEM allows simultaneous analysis to be performed for assessing the relationships among variables and errors, in addition to each variable being independently estimated.

Analysis of Moment Structures (AMOS) software (v. 24) was used in this study; maximum likelihood was the method for parameter estimation. Before testing for model fit in SEM, normality, reliability, and validity of the data was established. The overall model fit was assessed using the Tucker-Lewis index (TLI), the comparative fit index (CFI), root mean square error of approximation (RMSEA), and the Standardized root mean square residual (SRMR). The research model is depicted in Figure 1.

Results

Measurement Scales

Table 1 shows the mean and standard deviation of each of the items. All mean scores were above the midpoint of 3.00, indicating an overall positive response to the items used to measure the constructs in the study. The standard deviations ranged from .89 to 1.28, indicating a fairly narrow spread of scores around the mean. The values of the skewness and kurtosis for all the items ranged from -.01 to -.95 and .01 to 1.19, respectively. As recommended by Kline (2010), skewness and kurtosis indices should not exceed |3| and |10| respectively. Therefore, the data in this study was regarded as normal for the purpose of SEM.

Technological Pedagogical Content Knowledge of Trainee Teachers

Table 2 shows the mean scores of the subscales as measured by the TPACK survey. According to their responses, teachers seem to have very high Technological Pedagogical Knowledge (TPK) with score of 3.78 (*SD* = .84). This indicates that trainee teachers were aware of effective uses of technology in teaching, which reflects the ICT course content which emphasizes the integration strategies. In the ICT course, trainees were introduced to how different technologies can be employed in teaching subjects such as science, mathematics, and English language in primary schools. They were also exposed to evaluate a range of technologies commonly used to support digital learning and assessment. This awareness also includes understanding the affordances of technological tools and how to harness them in a proper way in their teaching.

Other components in the TPACK, such as CK and PK were lower 3.46 (*SD* =.79) and 3.47 (*SD* =.80) respectively. Again, the effect of CK and PK were found in PCK which also scored lower at 3.47 (*SD* = .77). This indicates that their knowledge of content alone was weak with limited pedagogical knowledge in delivering the content. It is also surprising to see that the TK score was the lowest. Although teachers were exposed to various technologies, they were not sure which technology can be used in their teaching. Regardless of those deficiencies, trainee teachers seem to have high TPACK scores. The composite reliability ranged from .80 to .91 and considered to be of high reliability.

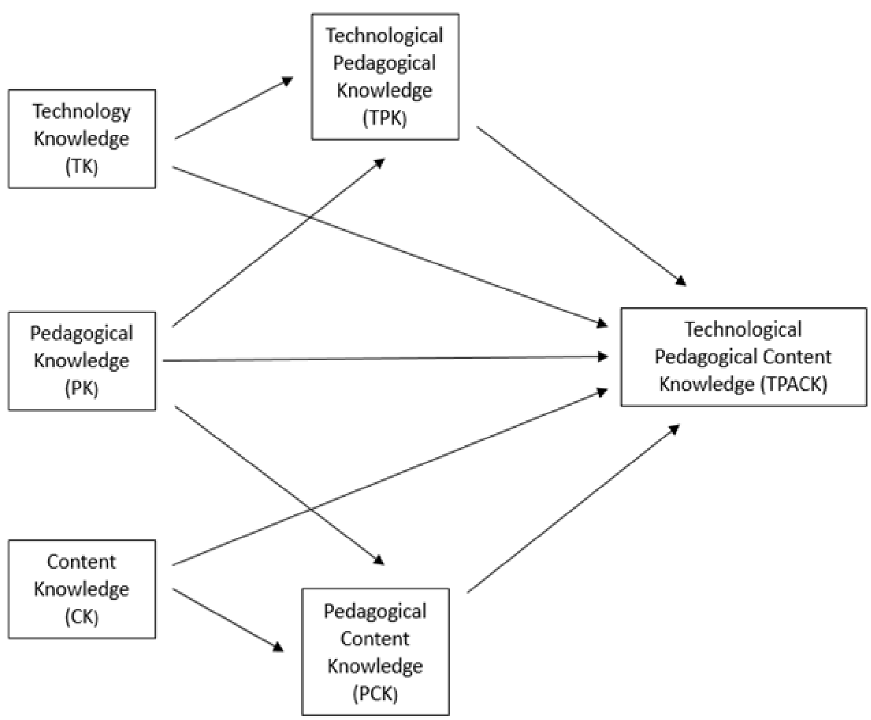

Figure 1. Research Model.

Table 1

Summary of Measurement Scales

Construct	Mean	SD	AVE
TK1	3.22	1.20	.61
TK2	3.65	1.29	
TK3	3.16	1.17	
TK4	3.54	1.13	
TK5	3.27	1.08	
TK6	3.37	1.14	
TK7	3.33	1.09	
CK1	3.43	.89	.52
CK2	3.16	.97	
CK3	3.46	.96	
CK4	3.67	1.15	
PK1	3.54	1.13	.53
PK2	3.59	.98	
PK3	3.35	1.00	
PK4	3.37	1.05	
PK5	3.65	1.02	
PK6	3.25	.92	
PK7	3.44	1.07	
PCK1	3.33	.97	.54
PCK2	3.49	1.05	
PCK3	3.56	.91	
PCK4	3.25	.95	
PCK5	3.44	1.13	
PCK6	3.35	1.03	
PCK7	3.62	1.08	
PCK8	3.68	1.03	
TPK1	3.83	1.01	.62
TPK2	3.59	1.12	
TPK3	3.94	.97	
TPK4	3.79	1.07	
TPK5	3.71	.99	
TPACK1	3.49	1.18	.67
TPACK2	3.68	.96	
TPACK3	3.75	1.18	
TPACK4	3.54	1.15	
TPACK5	3.62	1.10	

Table 2

Summary of Descriptive Statistics for Subscales of TPACK Components

Subscale	Number of Items	Responses	Mean	SD	Composite Reliability
TK	7	63	3.36	.95	.89
CK	4	63	3.43	.76	.80
PK	7	63	3.46	.78	.89
PCK	8	63	3.47	.78	.90
TPK	5	63	3.77	.85	.89
TPACK	5	63	3.62	.94	.91

CFA Analysis

The maximum likelihood estimation (MLE) procedure was chosen to assess the measurement model using CFA. The confirmatory factor analysis (CFA) is a statistical technique that is used to verify the factor structure of a set of observed variables. CFA allows testing the hypotheses that relationships between observed variables and their underlying latent constructs exist. The data in this study were examined using the Mardia's normalized multivariate kurtosis value (Mardia, 1970), since MLE procedure assumes multivariate normality of the observed variables. The Mardia's coefficient for the data was 44.79, which was lower than the value of 1368, using the formula $p\ (p + 2)$ where $p$is the number of observed variables in the model (Raykov & Marcoulides, 2008). Multivariate normality of the data was therefore assumed. Before testing the model, convergent and discriminant validities of the constructs were examined.

In establishing convergent validity of the measurement items, the item reliability, composite reliability (CR) and the average variance extracted (AVE) of each construct were examined (Fornell & Lacker, 1981). Item reliability of an item was assessed by its standardized factor loading onto the underlying construct (Teo, 2009). The composite reliability is computed by the sum of squared standardized factor loadings divided by the sum of squared standardised factor loadings and the sum of the error variance (Teo & Milutinovic, 2015). As recommended by Nunnally and Bernstein (1994), composite reliability is adequate with a minimum value of .70. The average variance extracted is a measure of the overall amount of variance that is attributed to the construct in relation to the amount of variance attributable to measurement error (Fornell & Larcker, 1981). Convergent validity is adequate when average variance extracted has a minimum value of .50. As seen in Table 1 and 2 and considering the average variance extracted, the composite reliability met the recommended guidelines which indicated that convergent validity in this study was adequate.

Discriminant validity assesses the variance shared between a construct and any other construct in the model (Fornell, Tellis & Zinkhan, 1982). If the square root of the AVE of a given construct is greater than the off-diagonal elements in the corresponding rows and columns, it suggests that the construct is more strongly correlated with its indicators than with the other constructs in the model (Teo, 2009). In Table 3, the values in parentheses in the main diagonal are the square roots of average variance extracted and suggest that discriminant validity was present at the construct level.

Table 3

Discriminant Validity for the Measurement Model

Construct	TK	CK	PK	PCK	TPK	TPACK
TK	**(.78)**					
CK	.27*	**(.72)**				
PK	.25*	.68**	**(.73)**			
PCK	.17	.59**	.68**	**(.73)**		
TPK	.54**	.54**	.56**	.55**	**(.79)**	
TPACK	.48**	.59**	.66**	.61**	.71**	**(.82)**

Note. The elements in bold and parentheses in the main diagonal are the square roots of average variance extracted.**$p < .01$; * $p < .05$

Table 4

Fit Indices for the Research Model

Model fit indices	Values	Recommended guidelines	References
χ^2	794.29; $p < 0.001$	Non-significant	Joreskog & Sorbom, 1996; Kline, 2010
df	545		
χ^2/df	1.46	< 3	Hu & Bentler, 1995; Kline, 2010
CFI	.92	≥ .90	Byrne, 2010; Hu & Bentler, 1999;
TLI	.91	≥ .90	Hu & Bentler, 1999
RMSEA	.053	< .05	Browne & Cudeck, 1993
SRMR	.048	< .05	Hu & Bentler, 1999; McDonald & Ho, 2002

Finally, Table 4 shows a summary of the overall model fit measures. The results of the model fit as shown by the various fit indices indicated that the research model fits the data fairly well.

Structural Model

The structural model and hypotheses were tested by examining the path coefficients and their statistical significance. The path coefficients presented in Figure 2 revealed that PK demonstrated a statistically significant association with TPK (path = .57, $p < .001$), TPACK (path = .53, $p < .05$), and PCK (path = .71, $p < .05$). Similarly, TK demonstrated a statistically significant association with TPK (path = .45, $p < .001$) and TPACK (path = .34, $p < .01$). Furthermore, CK demonstrated a statistically significant relationship with TPACK (path = .62, $p < .05$). The link between CK and PCK (path = .16) was statistically non-significant at the .05 level of variance. The impact of the second–level knowledge bases (TPK, PCK) on TPACK produced the results that TPK demonstrated statistically significant association with TPACK (path = .85, $p < .001$), but the relationship between PCK and TPACK was statistically non-significant (path = .04, $p > .05$).

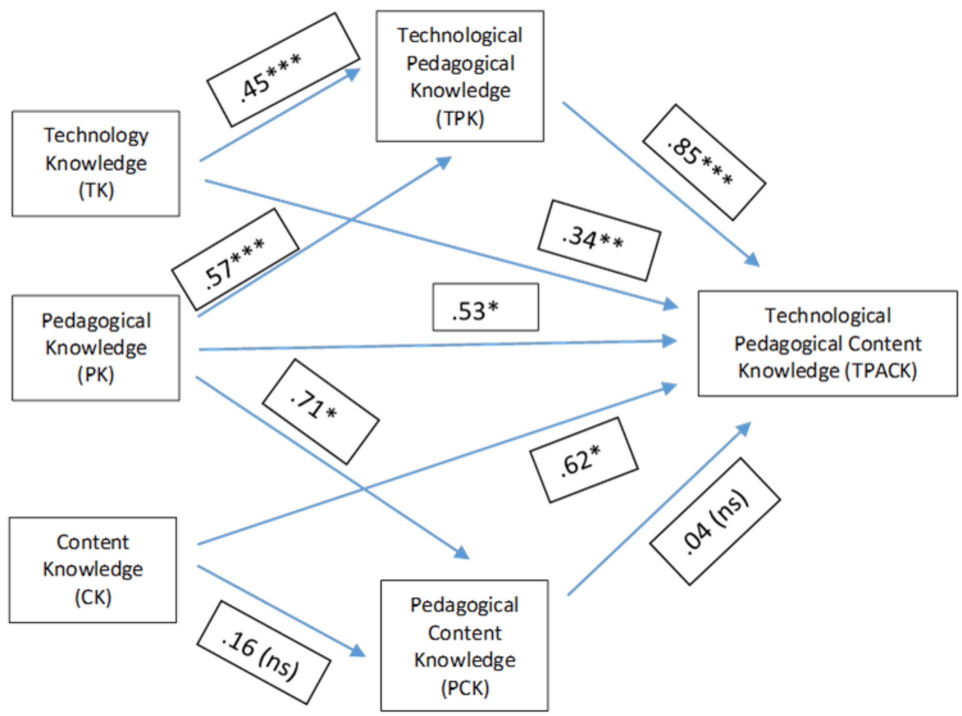

Figure 2. Structural Model of TPACK with path coefficients.
***$p < .001$; **$p < .01$; *$p < .05$, ns (non-significant)

Specifically, the model has produced three findings:

- Trainee teachers' sense of technological, pedagogical, and content knowledge will have a positive impact on the knowledge they need to teach effectively with technology.
- Trainee teachers' knowledge of how a lesson can best be delivered to meet learning goals and the fluency of how each technology functions have a positive relationship with their technology and pedagogical knowledge.
- CK was not related to PCK and PCK had no association with TPACK. This might be that the trainee teachers' do not believe that they have expert knowledge of the subject matter to impact pedagogical content knowledge, experiences, and technology to their students.

Three endogenous variables were tested in the research model. TPACK was found to be predicted by TK, PK, and CK, resulting in an R^2 of .72. This means that TK, PK, and CK explained 72% of the variance in TPACK. Further, TPK was found to be predicted by TK and PK, resulting in an R^2 of .64. This means that TK and PK explained 64% of the variance in TPK. Finally, PCK was predicted by PK, but CK was not statistically significantly related to PCK; this resulted in an R^2 of .59. The results of the hypotheses testing, path coefficients, *t*-values, and *R*-squares for the proposed model (Figure 1) are reported in Table 5.

Table 5

Standardized Path Coefficients, t-value and R-squares

Path	Standardized Path Coefficient	*t*-value	R-squares
TK→TPK	.45	3.94***	
TK→TPACK	.34	3.27**	
PK→TPK	.57	3.27***	
PK→TPACK	.53	2.38*	
PK→PCK	.71	2.13*	
CK→TPACK	.62	2.01*	
CK→PCK	.16	.55ns	
TPK→TPACK	.85	4.55***	
PCK→TPACK	.04	.21 ns	
TPK			64%
TPACK			72%
PCK			59%

***p< .001; **p< .01; *p< .05, ns (non-significant)

Discussion

This paper describes the validation of the TPACK questionnaire with pre-service teacher education students in one of the teacher training institutes in the Persian Gulf. The TPACK scales displayed satisfactory convergent and discriminant validities. This paper has also established pre-service teachers' perceived pathways to TPACK. Statistically significant relationships were found among seven out of nine hypotheses. The results suggest that TK, PK, CK, and TPK were positively related to TPACK, except for PCK which was not associated with TPACK. Findings from this study suggest that teachers' technological knowledge might be low compared to pedagogical knowledge and content knowledge. These findings are consistent with previous research which indicated that trainee teacher's basic knowledge about TK and PK were related positively to the TPK and the TRACK (Chai, Koh, & Tsai, 2011).

There is a need to review the content of the course and provide more practical experience in a range of new technologies for the students. Because this study was based solely on self-reported data, the interpretation of the results should be made with caution when inferring contribution to theory or educational phenomena. However, while there are limitations in self-reported data, validation of the instrument that measures a particular behaviour can be accepted as reliable.

All of the participants in this study were females. Some studies in the past demonstrated gender differences in technology integration in the classroom and attitudes towards technology (e.g., Heafner, 2014). Further studies are suggested to include male students, increase the sample size, and explore whether gender difference exists in this context. Future work can include a refined Arabic translation of the questionnaire.

Conclusion

According to Mouza and Karchmer-Klein (2013), pre-service teachers often learn about technology, content, and pedagogy in separate courses, which gives an incomplete picture of how technology can support learning. To achieve a complete TPAC Knowledge, teacher education programs must re-align their priorities to offer content, pedagogical skills, and technology know-how simultaneously in one course. Once they learn these three components together, students will gain both theoretical and practical knowledge that are intrinsically linked.

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