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Exploring the Factor Structure of the Constructs of Technological, Pedagogical, and Content Knowledge (TPACK): An Exploratory Factor Analysis Based on the Perceptions of TESOL Pre-Service Teachers at a British Private University in Malaysia

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Abstract

Using the TPACK framework, this research study investigated how pre-service teachers perceive their development of the knowledge, skills, and self-efficacy necessary for technology integration; and explored the opportunities that pre-service teachers have to learn about technology integration. It employed a convergent parallel mixed methods case study design. It has a single-embedded case design. The unit of analysis for inquiry is the undergraduate teacher preparation program at a private British university in Malaysia. This study incorporates quantitative data collection in the form of a survey alongside qualitative data collection conducted through semi-structured interviews. The participants for the survey comprised of three purposefully selected convenience samples of pre-service teachers (Years One, Two, and Three) studying the undergraduate teacher preparation program. Following the administration of the survey, a maximum variation sample of pre-service teachers who participated in the survey was invited for semi-structured interviews. The results indicated that the EFA found support for TK and CK being distinctive knowledge constructs within the pre-service teachers' knowledge perceptions. While PK, PCK, TPK, TCK, and TPACK were postulated to be distinct knowledge constructs in the TPACK framework, these were not reflected in the perceptions of the pre-service teacher participants of this study. Implications and recommendations are suggested.

Keywords: Pre-service teachers; Undergraduate; Technological knowledge; Private university.

1. Introduction

Recent decades have been characterised by accelerated technological utilisation. Globally, educational landscapes have undergone significant changes; schools are progressively adopting a wide variety of technological tools with which the enhancement of teaching and learning processes is believed to occur (Estes *et al.*, 2016; Keengwe and Onchwari, 2011). This phenomenon has brought critical implications for teacher preparation programmes.

1.1. Background of the Study

In order to enhance pre-service teachers' preparation in terms of their effective utilisation of technological tools, researchers and teacher educators have increasingly referred to the Technological, Pedagogical, and Content Knowledge (TPACK) theoretical framework. TPACK is used to describe the nuanced interactions among three bodies of teacher knowledge – content, pedagogy, and technology (Koehler and Mishra, 2008) – to enable teachers to make "intelligent pedagogical uses of technology" (Koehler *et al.*, 2007). It was constructed through the addition of technological knowledge (TK) to Shulman (1986) notion of pedagogical content knowledge (PCK) (i.e., content-specific knowledge for teaching) (Angeli and Valanides, 2009; Mishra and Koehler, 2006). Seven knowledge constructs constitute the TPACK framework – TK, content knowledge (CK), pedagogical knowledge (PK), PCK, technological content knowledge (TCK), technological pedagogical knowledge (TPK), and TPACK (Koehler and Mishra, 2008; Mishra and Koehler, 2006).

Since its conception, many teacher preparation programmes have been restructured with TPACK as their underpinning conceptual framework (Abbitt, 2011; Burns, 2007; Chai *et al.*, 2010; Harris and Hofer, 2009; Niess *et al.*, 2006; Niess, 2007; Shoffner, 2007). In addition, the TPACK framework has been utilised in surveys to assess pre-service teachers' perceptions of their knowledge and skills in integrating technology into their teaching practice

(Lux et al., 2011; Sahin, 2011; Schmidt et al., 2009). The reliability of such an assessment, however, first necessitates that the construct validity of the TPACK framework is firmly established. Several studies have developed surveys based on TPACK and tested its construct validity based on the perceptions of teachers in the USA (Archambault and Crippen, 2009; Schmidt et al., 2009) while others have attempted to do the same with teachers and pre-service teachers in different contexts (Jang and Tsai, 2012; Koh et al., 2010; Lee and Tsai, 2010; Nordin and Tengku Ariffin, 2016; Sahin, 2011; Shinas et al., 2013). The number of studies conducted in Malaysia, however, is scarce. Only one study (Nordin and Tengku Ariffin, 2016) has been conducted in a Malaysian public teacher preparation programme context to date. This creates a gap in the research literature that involves the exploration the construct validity of the TPACK framework based on the perceptions of pre-service teachers at private teacher preparation programme in Malaysia.

1.2. Problem Statement

While the TPACK framework is useful for conceptualising teacher knowledge, researchers have questioned its construct validity and applicability (e.g., (Angeli and Valanides, 2009; Archambault and Barnett, 2010). There appears to be some difficulty with respect to distinguishing the boundaries between the different knowledge constructs of the TPACK framework, which could likely be due to a lack of clarity around the definitions of these constructs (Cox and Graham, 2009; Graham, 2011). As Angeli and Valanides (2009) argue, “the explanations of technological pedagogical content knowledge and its associated constructs that have been provided are not clear enough for researchers to agree on what is and is not an example of each construct” (p. 60). As such, attempts to create robust instruments for conveniently measuring and assessing pre-service teachers’ TPACK are adversely affected (Albion et al., 2010; Graham, 2011), thus resulting in problems when addressing the effectiveness of teacher preparation programmes in preparing pre-service teachers to utilise technology in their future classroom instruction.

Nevertheless, the *Survey of Preservice Teachers’ Knowledge of Teaching and Technology* (SPTKTT) by Schmidt et al. (2009) has been claimed as the most promising self-report instrument employing the TPACK that has been designed to date. However, while this instrument may have been deemed efficient with high internal consistency reliability (Abbitt, 2011), recent studies have questioned its construct validity, and by extension, the TPACK framework (e.g., (Chai et al., 2010).

1.3. Significance of the Study

Empirical support for the TPACK framework is vital because it is being used to inform the development of pre-service teachers’ knowledge and skills for integrating technology into classroom instruction, and it also has critical implications for teacher preparation programmes (Shinas et al., 2013). Yet studies reporting on exploratory factor analyses (EFA) based on the TPACK perceptions of pre-service teachers have not confirmed the seven knowledge constructs of the TPACK framework (Voogt et al., 2012). Therefore, factor analyses research that examines the TPACK constructs (Archambault and Crippen, 2009), for example, as they have been described by Schmidt et al. (2009), in the SPTKTT is necessary to inform theory and practice. Findings from this study will help to illuminate whether content, pedagogy, and technology blend together to form the seven distinctive knowledge constructs of the TPACK framework. They will also provide significant implications for future research and practice, including the design of more robust survey instruments that measure and assess pre-service teachers’ TPACK development, and contribute further clarity about the TPACK framework (Shinas et al., 2013).

1.4. Purpose of the Study

Objective of the study. This study explored whether the perceptions of pre-service teachers resulted in a seven-construct model configuration that is supported by the TPACK framework.

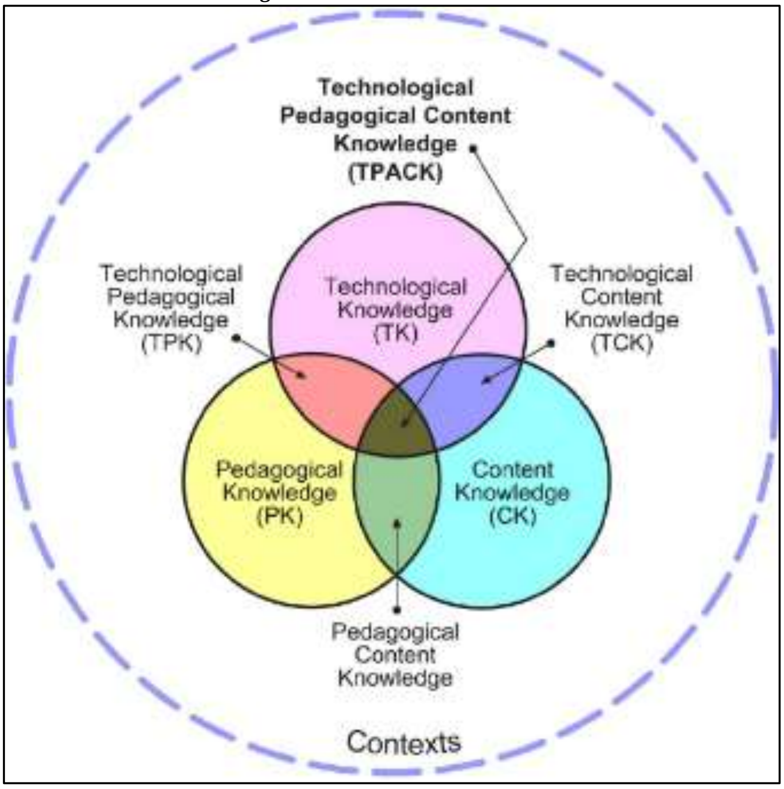
Aim of the study. This study examined the construct validity of the TPACK framework in *Schmidt et al.* (2009) SPTKTT through an EFA that was conducted based on the perceptions of a sample of pre-service teachers at a British Private University in Malaysia.

Research Question. This study was framed by the following research question: What do the responses of the pre-service teachers to the SPTKTT reveal about the factor structure, and by extension, the construct validity of the TPACK framework?

2. Literature Review

Koehler and Mishra (2009) posit that “at the heart of good teaching with technology are three core components: content, pedagogy, and technology, plus the relationships among and between them” (p. 62). Seven knowledge constructs – TK, CK, PK, PCK, TCK, TPK, and TPACK are included in the TPACK framework (see Figure 1; (Mishra and Koehler, 2006).

Figure-1. The TPACK Framework



The first three knowledge constructs are:
1. TK – knowledge of various technological tools
2. CK – knowledge of subject or content matter
3. PK – knowledge of the processes or methods of teaching

Harris *et al.* (2007) emphasised that the interactions between TK, CK, and PK formed the basis for teachers' technology integration expertise. Therefore, the four other knowledge constructs are:
4. PCK – knowledge of teaching methods for different types of subject matter
5. TCK – knowledge of subject matter representation with technology
6. TPK – knowledge of using technology to implement different teaching methods
7. TPACK – knowledge of using technology to implement teaching methods for different types of subject matter.

2.1. Surveys of Teachers' Knowledge Perceptions Using the TPACK Framework

Since the TPACK framework is widely utilised in teacher preparation programmes, it is necessary to develop instruments that are valid and reliable to measure TPACK and its related constructs (Archambault and Crippen, 2009; Archambault and Barnett, 2010; Chai *et al.*, 2010). As Schmidt *et al.* (2009) postulate, "using TPACK as a framework for measuring teaching knowledge could potentially have an impact on the type of training and professional development experiences that are designed for both preservice and inservice teachers" (p. 125). According to Shinas *et al.* (2013), only two mature instruments to measure TPACK knowledge constructs have been developed to date – one targeting inservice online teachers (Archambault and Crippen, 2009) and the other targeting pre-service teachers (Schmidt *et al.*, 2009).

Archambault and Crippen (2009) developed a survey instrument underpinned by the TPACK framework that consisted of 24 items that were designed to measure online teachers' TPACK knowledge. The items were written based on the definitions provided by Koehler and Mishra (2005) and Shulman (1986). Following content validity testing and extensive piloting, the survey was administered to 596 online teachers. Factor analysis using varimax rotation with all 24 items in the survey revealed only three distinct factors (PCK, TCK, and TK) instead of the seven knowledge constructs suggested by the TPACK framework. Furthermore, technology was the only clear domain that was clearly distinguishable.

Similarly, Schmidt *et al.* (2009) developed and validated the SPTKTT to measure pre-service teachers' self-assessment of their TPACK. This survey was also grounded in the TPACK framework as proposed by Mishra and Koehler (2006) and was designed to measure all seven knowledge constructs. The survey extended to general contexts, multiple content areas, and multiple approaches to professional development. Yet it was specifically designed for pre-service teachers who major in elementary or early childhood education and was focused on the content areas that they will be teaching in their future classrooms. The development of the survey consisted of a progression through various stages, whereby Schmidt and colleagues first reviewed other pilot instruments reported in the literature and solicited feedback from content experts. Based on that feedback, they constructed a 75-item survey and administered it to a group of 124 pre-service teachers. Subsequently, the construct validity for each knowledge construct was examined using factor analysis. However, due to the small sample size, factor analysis was performed on the items within each subscale instead of the entire instrument. Based on this analysis, problematic issues were identified, and individual items were revised or eliminated, resulting in a revised instrument that consisted of 47 items. Reliability statistics were then re-calculated for each knowledge construct, and the results demonstrated high levels of internal consistency reliability.

Chai *et al.* (2010), used a modified version of the SPTKTT developed by Schmidt *et al.* (2009) and examined the TPACK development of a sample of 889 pre-service teachers who were enrolled in a postgraduate teacher preparation programme in Singapore. This instrument consisted of 18 modified items specific to the experiences of pre-service teachers in Singapore. Analysis revealed a four-factor model – TK, PK, CK, and TPACK – instead of the seven knowledge constructs identified by TPACK theorists and validated by Schmidt *et al.* (2009).

Similarly, Koh *et al.* (2010) utilised a modified version of the SPTKTT to examine its construct validity through an EFA of a large sample of pre-service teachers in Singapore. Results revealed a five-factor model which consisted of TK, CK, knowledge of pedagogy (KP), knowledge of teaching with technology (KTT), and knowledge of critical reflection (KCR). The participants experienced difficulties in distinguishing between general PK and PCK, therefore these items were relabelled as KP. Likewise, the participants had difficulty distinguishing among TPK, TCK, and TPACK, so these items were relabelled as KTT. Overall, this study also did not provide support for the seven knowledge constructs as described in the TPACK framework.

The most recent study that conducted an EFA to examine the construct validity of TPACK through the SPTKTT is that of Shinas *et al.* (2013). The participants for this study were 365 pre-service teachers who were enrolled in an educational technology course in the USA. Results yielded eight factors that were similar to those reported by Schmidt *et al.* (2009) but contradictory to the four-factor model reported by Chai *et al.* (2010) and the five-factor model reported by Koh *et al.* (2010). It is important to note that in this study, all 47 items in the SPTKTT (Schmidt *et al.*, 2009) were administered to participants. In contrast, Chai *et al.* (2010) and Koh *et al.* (2010) revised the SPTKTT so that only 18 and 29 items were administered respectively.

All the studies discussed above have been conducted either in the USA (Archambault and Crippen, 2009; Schmidt *et al.*, 2009; Shinas *et al.*, 2013) or Singapore (Chai *et al.*, 2010; Koh *et al.*, 2010). In the Malaysian context, Nordin and Tengku Ariffin (2016) conducted a confirmatory factor analysis (CFA) instead of an EFA to validate a TPACK instrument that comprised of items from Schmidt *et al.* (2009) and Archambault and Crippen (2009). The aim of this study was to confirm the seven-construct TPACK model using the responses of 150 pre-service teachers who were enrolled in a public university in Malaysia. The results revealed that the measurement model adequately fit with the data collected, therefore also lending validity to the adapted TPACK instrument used in this study.

2.2. Gaps

Based on a review of previous research, it appears that the construct validity of the SPTKTT has yet to be established. This is applicable not only to the USA, Singapore, and other contexts, but to Malaysia as well. With the exception of Nordin and Tengku Ariffin (2016), no study conducted in Malaysia has attempted to do an exploratory analysis of the seven-construct model supported by the TPACK framework. Furthermore, Nordin and Tengku Ariffin (2016) did not conduct an EFA, but instead utilised a CFA since they intended to confirm the seven-construct model based on the perceptions of Malaysian pre-service teachers. Therefore, more studies based on the perceptions of pre-service teachers pursuing teacher preparation programmes in Malaysia are still needed to examine the construct validity and applicability of the seven-construct TPACK model.

2.3. Methodology

This study employed factor analysis which involves the utilisation of mathematical procedures to enable the discovery of patterns in a set of variables through the simplification of interrelated measures (Child, 2006). The notion upon which factor analysis operates is the reduction of dimensionality whereby measurable and observable variables are reduced to fewer latent variables that share a common variance and are unobservable (Bartholomew *et al.*, 2011). These unobservable factors are not directly measured but are essentially hypothetical constructs that are used to represent variables (Cattell, 1973).

This study utilised an EFA instead of a CFA since the former tries to uncover complex patterns through the exploration of the dataset and the testing of predictions while the latter attempts to confirm hypotheses and uses path analysis diagrams to represent variables and factors (Child, 2006). Therefore, this study intended to use an EFA as an “exploratory” tool (Costello and Osborne, 2005) to discover the number of factors influencing the variables of the TPACK framework and to analyse which of these variables ‘go together’ (DeCoster, 1998) without a pre-specification of the number of factors that can emerge (Brown, 2006). The utilisation of an EFA also helped to determine if the test items clustered towards the factors that they were designed to measure (Thorndike, 2005). The basic hypothesis of this study was that there were *m* common ‘latent’ factors to be discovered in the dataset obtained through survey administration, and the aim was to determine the smallest number of common factors that will account for the correlations (McDonald, 1985). Besides, EFA was deemed as a suitable analytical approach for this study since there was “relatively little prior theory and empirical evidence” (Fabrigar *et al.*, 1999) about the construct validity of the TPACK framework.

2.4. Context

This study was conducted in the context of an undergraduate teacher preparation programme at a British Private University in Malaysia. Students enrolled in this programme specialise in Teaching English to Speakers of Other Languages (TESOL), but also study general modules related to the field of Education, including educational psychology, sociology, and special needs. In this course, educational technology is not taught as a separate module. Instead, it is integrated across all modules. The effectiveness of this method of embedding technology tools and strategies throughout all pre-service classes has been established in the literature (Koehler *et al.*, 2007; Park *et al.*, 2010). Koehler *et al.* (2007), had called for a move away from stand-alone technology courses, explaining that technology utilisation in teaching should always be viewed in the context of the content being taught and the pedagogies being employed. They argued that technology integration is unlikely to be promoted through de-contextualised approaches. Therefore, the setting of this study seems feasible, as given its hybrid nature, technology integration frameworks such as the TPACK framework is best developed in the context of pre-service courses which provide meaningful context whereby instruction on how to utilise technological tools can be pedagogically situated in the teaching of subject matters (Davis and Falba, 2002; Zhou and Xu, 2007).

2.5. Sample

This study employed simple random sampling, whereby every pre-service teacher who was pursuing the undergraduate teacher preparation programme at the time of this study had an equal chance of being included. At the beginning of the February 2019 (spring) semester, an invitation to participate in the survey along with the information sheet and consent form, were sent to all year groups (one, two, and three) via email. Participation was voluntary, and the respondents accessed the survey via an attachment in the email. By the end of the survey administration period, a total of 37 responses out of 60 pre-service teachers were received, constituting a response rate of 61.67%. Of the 37 respondents, 33 (89.19%) respondents were female. 18 (48.65%) were Year One pre-service teachers, 12 (32.43%) were Year Two pre-service teachers, and 7 (18.92%) were Year Three pre-service teachers.

For an EFA, the recommended sample size is at least 300 participants, and the variables that are subjected to factor analysis each should have at least 5 to 10 observations (Comrey and Lee, 1992). Furthermore, the ratio of respondents to variables should be at least 10:1 and factors are considered to be stable and to cross-validate with a ratio of 30:1 (Yong and Pearce, 2013). A larger sample size is therefore recommended as it diminishes the error in the data.

Although the sample size of this study is relatively small, it is acceptable for an EFA. The sample size is not critical provided that the factors are over-determined with high communalities (Budaev, 2010). In fact, Reyes Jr. *et al.* (2016) conducted an EFA for a similar study with a sample of 39 pre-service teachers and successfully identified a four-construct configuration of pre-service teachers' TPACK perceptions.

2.6. Data Collection Instrument and Procedures

The SPTKTT (Schmidt *et al.*, 2009) is a validated survey instrument designed to measure the development of pre-service teachers' TPACK. A review was initially conducted to determine how the subject matter of TESOL could be incorporated into the SPTKTT since the original instrument described the items that contained an element of content (e.g., CK, PCK, TCK, TPACK) according to the curriculum areas of mathematics, science, literacy, and social sciences. After the review, it was found that modifications were possible without substantial changes being made to the survey items. Therefore, the items of CK, PCK, TCK, and TPACK were modified to address TESOL content. For example, the item 'I know how to select effective teaching approaches to guide student thinking and learning in mathematics', was changed to 'I know how to select effective teaching approaches to guide student thinking and learning in TESOL'. 11 questions that were not relevant to the objectives of this study were also removed. These were questions related to pre-service teachers' assessment of their professors' TPACK. All other questions designed to measure TK, PK, and TPK were retained.

Of the original 47, 29 items specific to the seven knowledge constructs of the TPACK framework were administered. Since Thorndike (2005) recommended that the reliability of a scale increases when the options within a range are more numerous, the five-point Likert scale in the original SPTKTT was changed to a seven-point Likert-scale in this study where: (1) strongly disagree; (2) disagree; (3) slightly disagree; (4) neither agree nor disagree; (5) slightly agree; (6) agree; and (7) strongly agree. The survey data was entered into the Statistical Package for the Social Sciences (SPSS). Cronbach (1951) coefficient alpha for the 29 items measuring TPACK in this data set was .936, which is in line with scores reported by Schmidt *et al.* (2009). This provided reasonable evidence that the internal consistency of the adapted SPTKTT was reliable (Sprinthall, 2007).

2.7. Data Analysis Procedures

For the EFA, Principal Axis Factor analysis was employed due to its relative tolerance of multivariate normality and superior recovery of weak factors (Briggs and MacCallum, 2003; Cudeck, 2000; Fabrigar *et al.*, 1999). Communalities were estimated through squared multiple correlations and were iterated to produce final communality estimates (Gorsuch, 2003). For both theoretical and empirical reasons, this study assumed that the retained factors would be correlated, therefore a Promax rotation with Kaiser Normalisation ($k = 4$) was employed (Tataryn *et al.*, 1999). Items were eliminated if their loadings were less than 0.40 (Tabachnick and Fidell, 2007), or when there were cross-loadings (i.e., when an item loads at .32 or higher on two or more factors) (Bentler, 1990; Costello and Osborne, 2005). The EFA was re-run until there were no factor loadings below 0.40 and cross-loadings of factors.

One of the more critical decisions in an EFA is to determine the correct number of factors to retain and rotate (Fabrigar *et al.*, 1999; Tabachnick and Fidell, 1996). The most common rule is to retain factors when the eigenvalues are greater than 1.0 (Kaiser, 1960). However, this solitary criterion, which is the default procedure in most statistical packages, tends to under or overestimate the number of true latent dimensions (Costello and Osborne, 2005; Field, 2009; Gorsuch, 1983; Velicer *et al.*, 2000; Zwick and Velicer, 1986). Accordingly, each model was evaluated against two criteria: (a) eigenvalues greater than 1.0 (Kaiser, 1960) and (b) scree test (i.e., scree plot) (Cattell, 1966).

3. Results

3.1. Descriptive Statistics

Table 1 presents the means (Ms) and standard deviations (SDs) for the 29 variables submitted to the EFA.

Table-1. Means and Standard Deviations: SPTKTT (Schmidt *et al.*, 2009)

Variable	M	SD
TK 1	4.81	1.371
TK 2	5.32	1.056
TK 3	4.46	1.445
TK 4	4.73	1.283
TK 5	4.24	1.402
TK 6	4.76	1.038
TK 7	4.41	1.384
CK 1	4.70	1.412
CK 2	4.73	1.217
CK 3	4.78	1.205
PK 1	5.03	1.142
PK 2	5.35	.753
PK 3	5.16	.958
PK 4	5.16	1.041
PK 5	5.16	.958
PK 6	4.68	1.270
PK 7	4.89	1.075
PCK 1	4.70	1.102
TCK 1	4.57	1.281
TPK 1	5.03	1.142
TPK 2	5.05	1.153
TPK 3	5.43	1.463
TPK 4	5.35	1.399
TPK 5	5.14	1.110
TPACK 1	4.73	1.122
TPACK 2	4.97	1.040
TPACK 3	4.81	1.101
TPACK 4	4.51	1.121
TPACK 5	5.03	1.190

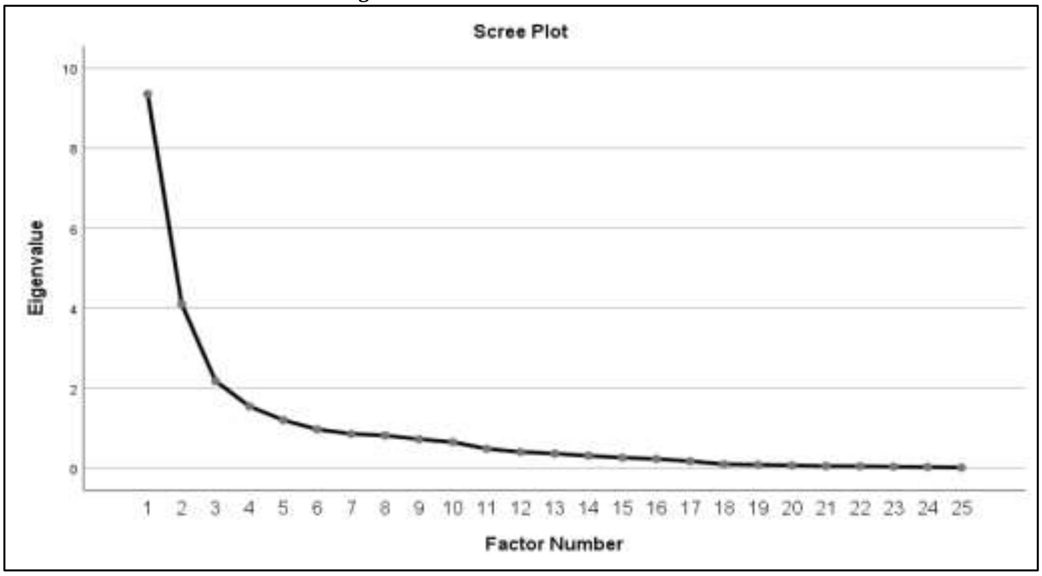
3.2. Bartlett's Test of Sphericity and Kaiser-Meyer-Olkin

Results from the Bartlett's Test of Sphericity (Bartlett, 1954) indicated that the correlation matrix was not random (x^2 = 798.546; df = 300; p = .000). Statistical significance was reached ($p < .001$) indicating that the correlations were sufficiently large for the EFA. The Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO; (Kaiser, 1974) statistic was .605. It is slightly above the .60 minimum that Kline (1994) suggested and is considered acceptable by Taherdoost *et al.* (2014).

3.3. Scree Test

The scree plot pointed to five-factor solution when eigenvalues greater than 1.0 were considered (see Figure 2).

Figure-2. Scree Plot: Five-Factor Solution



3.4. Rotated Pattern Matrix

The five factors in the rotated pattern matrix were interpreted according to the magnitude and meaning of their salient pattern coefficients. All coefficients greater than or equal to .40 were considered appreciable (Tabachnick and Fidell, 2007). The factor loadings from the EFA is presented in Table 2. All items loaded with coefficients greater than .500, with the exception of TPACK 3 which has the lowest coefficient of .489.

Table-2. Factor Loadings from EFA

	Factor loadings
Factor 1 – Technological Knowledge (TK, α = .868)	
TK 1 – I know how to solve my own technical problems	**.737**
TK 2 – I can learn technology easily	**.642**
TK 3 – I keep up with important new technologies	**.662**
TK 4 – I frequently play around with the technology	**.848**
TK 5 – I know about a lot of different technologies	**.780**
TK 6 – I have the technical skills I need to use technology	**.592**
TK 7 – I have had sufficient opportunities to work with different technologies	**.563**
Factor 2 – Content Knowledge (CK, α = .927)	
CK 1 – I have sufficient knowledge about TESOL	**.500**
CK 2 – I can use a TESOL way of thinking	**.721**
CK 3 – I have various ways and strategies of developing my understanding of TESOL	**.898**
Factor 3 – Knowledge of Pedagogy (KP, α = .896)	
PK 1 – I know how to assess student performance in a classroom	**.627**
PK 2 – I can adapt my teaching based upon what students currently understand or do not understand	**.849**
PK 3 – I can adapt my teaching styles to different learners	**.708**
PK 4 – I can assess student learning in multiple ways	**.836**
PK 5 – I can use a wide range of teaching approaches in a classroom setting	**.774**
PK 7 – I know how to organise and maintain classroom management	**.723**
PCK 1 – I can select effective teaching approaches to guide student thinking and learning in TESOL	**.572**
Factor 4 – Knowledge of Teaching with Technology (KTT, α = .904)	
TCK 1 – I know about technologies that I can use for understanding and doing TESOL	**.817**
TPK 1 – I can choose technologies that enhance the teaching approaches for a lesson	**.865**
TPK 2 – I can choose technologies that enhance students' learning for a lesson	**.783**
TPACK 2 – I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn	**.543**
TPACK 3 – I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom	**.489**
Factor 5 – Knowledge from Critical and Creative Reflection (KCCR, α = .864)	
TPK 3 – My teacher preparation programme has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom	**.744**
TPK 4 – I am thinking critically about how to use technology in my classroom	**.822**
TPK 5 – I can adapt the use of the technologies that I am learning about to different teaching activities	**.739**

Several items – TPACK 4, PK 6, TPACK 1, and TPACK 5 – were eliminated during the EFA. TPACK 4 ("I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school and/or district") was deemed to be irrelevant to the pre-service teachers who currently do not engage in leadership activities at the school and/or distinct level. PK 6 ("I am familiar with common student understandings and misconceptions"), TPACK 1 ("I can teach lessons that appropriately combine TESOL content, technologies, and teaching approaches"), and TPACK 5 ("I can choose technologies that enhance the content for a lesson") were eliminated due to their low values and the presence of cross-loadings. The final model was composed of five factors that explained 73.5% of the total variance. The five sources of teacher knowledge were (see Table 2) TK, CK, KP, KTT, and Knowledge from Critical and Creative Reflection (KCCR). All rotated factors had at least 3 variables consistent with the suggestion made by Tabachnick and Fidell (2007).

The construct validity of this TPACK survey was supported with respect to TK and CK. The items to measure these constructs emerged as two distinct factors as postulated by the TPACK framework. The third factor was composed of items for PK and PCK. The participants of this study did not differentiate between their knowledge of general pedagogies (e.g., classroom management, assessment) and how such knowledge was utilised to teach particular content areas. Therefore, the items for PK and PCK were re-labelled as KP. The fourth factor comprised of all TCK, all TPACK, and some TPK items (i.e., TPK 1 and TPK 2). The participants interpreted the items related technology as being conceptually similar. The fifth factor was composed of the items TPK 3, TPK 4, and TPK 5. The first two – TPK 3 and TPK 4 – were related to the pre-service teachers' reflection about technology integration. Meanwhile, TPK 5 was related to creative reflection because it involved the adaptation of the use of technologies that the pre-service teachers were learning about to different teaching activities. This is the only item that has any element of creativity (i.e., adaptation), as the other items in the survey were only related to knowing, comprehending, and applying (the first three levels of Bloom's Taxonomy) technologies into classroom instruction. Therefore, these items were re-labelled as KCCR. The alpha coefficients for these factors ranged from .864 (KCCR) and .927 (CK) (see Table 2), indicating highly adequate internal consistency in the assessment of pre-service teachers' perceptions of the knowledge constructs of TPACK.

The relative independence of scores among the scales was also calculated by comparing the correlations among the rotated factors. Correlations between the retained factors varied (see Table 3). Importantly, the correlations between KP and KCCR was the highest at .500.

Table-3. Factor Correlation Matrix

Factor	TK	CK	KP	KTT	KCCR
TK	1.000	.035	.322	.419	.491
CK	.035	1.000	.412	.256	.318
KP	.322	.412	1.000	.481	.500
KTT	.419	.256	.481	1.000	.474
KCCR	.491	.318	.500	.474	1.000

Note: *N* = 37. Extraction Method: Principle Axis Factoring; Rotation Method: Promax with Kaiser Normalisation.

In addition, Cronbach (1951) coefficient alpha was calculated to estimate the internal-consistency reliability for the five factors, producing robust results (Iacobucci and Duhachek, 2003). The overall Cronbach's alpha was .92. Reliabilities greater than .70 are recommended (e.g., (Allen and Yen, 1979; Thorndike, 1982).

4. Discussion

This study supported the internal reliability of the TPACK survey items reported by Schmidt *et al.* (2009). The EFA established the construct validity for the items of TK and CK. However, the other items were interpreted as three distinct factors – KP, KTT, and KCCR. While the participants of this study perceived conceptual differences between teaching with and without technology (i.e., KP and KTT), they were unable to differentiate the related constructs within each factor. A new factor, KCCR, also emerged in this study. These findings will be discussed below in three themes – (1) inexperience of the pre-service teachers, (2) general versus contextualised TPACK, and (3) critical and creative reflection and TPACK.

4.1. Inexperience of the Pre-Service Teachers

The merging of the items of PK and PCK into the factor KP could be explained by the relative inexperience of the participants of the study in the teaching profession. This is similar to the findings of Koh *et al.* (2010). Several studies considering PCK have found that pre-service teachers possessed less capabilities in terms of considering the relationships between content and pedagogy as compared with expert teachers (Copeland *et al.*, 1994; Leinhardt, 1989; Sabers *et al.*, 1991). Most participants of this study were just beginning or halfway through their teacher preparation programme. This could explain why they probably lacked deep knowledge and experience of the teaching practice. Therefore, it was difficult for them to distinguish between PK and PCK, consistent with the findings of Lee and Tsai (2010). Besides, the relative inexperience of the participants could also explain the merging of the items for TCK, TPK, and TPACK into the factor KTT.

4.2. General Versus Contextualised TPACK

The participants of this study may have also failed to differentiate between the items of TCK, TPK, and TPACK because these items did not include specific examples of technological integration (see Table 2). For example, TPACK 3 ("I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom") was not supplemented with examples of technological tools and strategies that featured the amalgamation of CK, PK, and TK. Such an approach may have assisted the participants in distinguishing the items for TCK and TPK from the TPACK items. Moreover, Angeli and Valanides (2009) proposed that TPACK had a transformative epistemological nature whereby knowledge is described as a unique synthesis instead of a simple combination of parts (Gess-Newsome, 1999). Cox and Graham (2009) further suggested that TCK and TPK could exist as more general knowledge forms while TPACK was contextualised to specific topics and lesson activities. The merging of TCK and TPACK in this study is similar to the findings of Koh *et al.* (2010) but contradictory to the findings of Lee and Tsai (2010) who identified them as two distinct factors when implementing a subject-specific survey. Therefore, there should be more comparisons of construct validation results between generic and contextualised TPACK surveys (Koh *et al.*, 2010).

4.3. Critical and Creative Reflection and TPACK

The five TPK items were split between KTT and KCCR during the EFA (see Table 2). This implied that the participants of this study perceived that there were conceptual differences between the choosing of technological tools (TPK 1 and TPK 2), and their reflection about their technology utilisation (i.e., TPK 3, TPK 4, and TPK 5). Indeed, as Shulman (1999) proposed, reflection aids teachers in their formulation of new insights about content, pedagogy, and students, and this enhances their pedagogical reasoning. This makes KCCR a significant TPACK construct that may warrant further examination.

Koh *et al.* (2010) had a construct which included three items – TPK 3 and TPK 4 – and labelled it as knowledge from critical reflection (KCR). This study, however, included TPK 5 along with TPK 3 and TPK 4 in the same construct (factor 5) and labelled it as knowledge from critical and *creative* reflection (KCCR). The creative element of KCCR is attributed to TPK 5 ("I can *adapt* the use of the technologies that I am learning about to different teaching activities"). Adaptation is a component of creation, the highest level in the revised Bloom's Taxonomy (Anderson and Krathwohl, 2001).

5. Conclusion

This study reported on the construct validity of the TPACK framework in the SPTKTT through an EFA using a sample of TESOL pre-service teachers at a British Private University in Malaysia. Findings indicated that this sample of pre-service teachers did not confirm the findings of the factor analysis reported by Schmidt *et al.* (2009). The EFA found support for TK and CK being distinctive knowledge constructs within the pre-service teachers' knowledge perceptions. While PK, PCK, TPK, TCK, and TPACK were postulated to be distinct knowledge constructs in the TPACK framework, these were not reflected in the perceptions of the pre-service teacher participants of this study. Therefore, there is a necessity for more research that can validate the TPACK framework as a better comprehension of "its epistemological foundations, components and methods will contribute immensely to improving the predictive ability of this model" (Koh *et al.*, 2010).

6. Limitations

As noted by Archambault and Crippen (2009), one of the limitations of any research that utilises the SPTKTT is that it is a self-report measure. While the participants completed the survey outside of class time in order to reduce potential bias, self-report measures are subject to bias that may be difficult to control. Therefore, pre-service teachers' explanations of their experiences with and interpretation of the items could be obtained in order to aid the determination of the reasons why different factor structures tended to load together (Koh *et al.*, 2010).

Besides, this study only applied two criteria when deciding on the number of factors to retain and rotate. These were (a) eigenvalues greater than 1.0 (Kaiser, 1960) and (b) the scree test (Cattell, 1966). Evaluation could have been strengthened through the application of three other criteria such as (a) Glorfeld (1995) extension of parallel analysis (PA; (Horn, 1965), (b) minimum average parcels (MAP; (Velicer, 1976), (c) interpretability (Fabrigar *et al.*, 1999; Gorsuch, 1983), and (d) Exploratory Graph Analysis (Golino and Epskamp, 2017).

Implications

The difficulty faced by pre-service teachers in conceptualising specific knowledge constructs of the TPACK framework suggests the necessity for the (a) development of more concrete definitions of these constructs, including a reconsideration of the necessity of individual constructs and (b) design of more precise survey items that can measure these constructs (Shinas *et al.*, 2013). Yet researchers continue to struggle to form clear articulations of the boundaries between all constructs and to offer consistent definitions for each of them (Cox, 2008; Hofer and Harris, 2012). Cox (2008), for instance, identified ten definitions of TCK in the literature. As such, this may result in inconsistencies in research findings (Hofer and Harris, 2012). Hence, as Shinas *et al.* (2013) suggests, "more concrete and applied definitions of TPACK constructs will help develop more consistent and precise survey instruments" (p. 355). They also posit that there should be some consideration in relation to the inclusion of content-specific items related to TCK and TPACK to emphasise the content-specific nature of technology integration that is highlighted in the TPACK framework.

Recommendations for Future Research

The results of this study point to several critical areas for future research. First, more items related to KCCR can be added to strengthen the measurement of this construct. This includes examples such as the critical reflection of pre-service teachers' personal education experiences with ICT and of their pre-service teaching experiences. Items related to creative reflection could include those that are related to the higher levels of any creativity taxonomy (Batey, 2012; Kirschenbaum, 1998; Nilsson and van Driel, 2011).

Second, construct validation studies can be carried out using various approaches. For example, this study could be replicated with teachers who are known to be exemplary technology integrators to determine if they could make clear distinctions between all the constructs of the TPACK framework. This could not be explored in this study as the participants were pre-service teachers, most of whom lacked any form of teaching experience. Comparative studies of generic and subject-specific TPACK surveys can also be carried out in order to ascertain the robustness of context-specific TPACK items. The cross-cultural validity of this TPACK survey can also be examined by replicating it different countries and types of teacher preparation programmes.

Third, there should be further investigation into the relationship between the TPACK constructs and teachers' demographic variables such as age, gender, and teaching level. There exists a need to examine if these variables exert stronger influence on the TPACK perceptions of both pre-service and in-service teachers because this will inform the structure and planning of teacher preparation programmes.

Future research can also investigate the role of TPACK surveys in supporting ICT programme evaluation (Koh *et al.*, 2010). Many qualitative studies that provide rich details about interventions utilised for the development of teachers' TPACK have been conducted. Some of these include teacher engagement in designing ICT lessons (Angeli and Valanides, 2009; Mishra and Koehler, 2006), microteaching activities (e.g., (Cavin, 2008), action research projects (e.g., (Lundeberg *et al.*, 2003). Therefore, both pre- and post- course TPACK surveys can be utilised as supplements to qualitative analysis of teachers' TPACK development during such programmes. As posited by Koh *et al.* (2010), "triangulation of qualitative findings with survey results can contribute to the development of a common vocabulary to describe teachers' TPACK development" (p. 571).

Finally, future research might also consider the examination of the TPACK framework from a "transformative" perspective (Shinas *et al.*, 2013). This perspective treats TPACK as a unique and synthesised body of knowledge that is more than the simple sum of its parts (Gess-Newsome, 2002). Much of the survey work conducted till date has applied an integrative perspective in which TPACK is viewed as the combination of different knowledge constructs (Graham, 2011). Such work (e.g., (Shinas *et al.*, 2013), including this study, has possibly established less than satisfactory acceptable levels of discriminant validity for the TPACK constructs (Archambault and Crippen, 2009; Archambault and Barnett, 2010; Burgoyne, 2010). The implementation of a transformative perspective will not require researchers to measure all the knowledge subconstructs, but instead identify the items that reflect TPACK as a unique knowledge base.

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