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Validating the Technological Pedagogical Content Knowledge appropriate for instructing Students (TPACK-S) of pre-service teachers

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Abstract

Based on Mishra & Koehler's idea of Technological Pedagogical Content Knowledge (TPACK), a student component had been added to form the Technological Pedagogical Content Knowledge (TPACK) appropriate to instruct student model (TPACK-S) as a useful frame to grasp complete teacher knowledge. The primary purpose of the present study was to validate the newly developed TPACK-S measurement model consisting of 15 components. Data for this pilot study were collected using the five-level Like scale questionnaires from a sample of 135 student teachers, analyzed using confirmatory factor analysis, and estimated psychometric properties. The research results indicated that the TPACK-S measurement model fit the empirical data. Internal consistency between the individual factors was also strong. The implied policy implication is that the teacher equipped with TPACK-S would enhance students' achievement.

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Keywords: Technological Pedagogical Content Knowledge appropriating for students (TPACK- S), model validation, pre-servic teachers, student teachers

1. Introduction

Mishra and Koehler (2006) had developed the Technological Pedagogical Content Knowledge (TPACK) framework consisting of seven cognitive tools deriving from a critical synthesis of the knowledge employed by most of the effective teachers, and had further elaborated the framework as a way to develop the specialized knowledge, skills, and understanding that teachers must have to become effective classroom teachers towards the 21st learning of students (Mishra, Kohler and Henriksen 2011). In the TPACK framework (see Figure 1A), there are three main components of *Technological Knowledge* (TK) referring to basic and advance technologies, Pedagogical Knowledge (PK) referring to instructional method process and practices, and *Content Knowledge* (CK) referring to the subject matters the students should have learned; and the four integrated components as a results of the interactions among TK, PK, and CK, consisting of *Technological Pedagogical Knowledge* (TPK), *Technological Content Knowledge* (TCK), Pedagogical Content Knowledge (PCK) and *Technological Pedagogical Content Knowledge* (TPACK) as the central component of all. The framework has been conceptually developed and assessed to signify it as a perfect guideline for the development of the pre-service teachers.

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Recently educators in general and educational technologists in particular have been trying to empirically proved the validity of the of the seven-component TPACK measurement model of the teachers' knowledge (Koehler , Mishra & Yahya, 2007; Hsu, 2012; Kafyulilo, 2010; Schmidt, Sahin, Thompson & Seymour, 2008; Jang, 2012; Chai, 2011). Almost all of those efforts used exploratory factor analysis, and consequently, yielded different numbers of TPACK components. For example, Archambault and Barnett (2010) found only three components, Lux (2011) found six factors, and Koehler, Shin, and Mishra (2011) and Lee and Tsai (2010) and Chai (2011) discovered five components. The differences in those research findings could be explained either by variations in the studied samples, contents, measures, or the limitation of the data analysis compared to the confirmatory factor analysis. (Jöreskog and Sörbom, 1996; Hair, Black, Babin and Anderson 2010). Being aware of the analytically limitation, Saengbanchong, Wiratchai and Bowarnkitiwong (2012) have attempted using second order confirmatory factor analysis to validate the TPACK measurement model developed based on Schmidt, et al. (2009), and successfully found that the developed TPACK model has been strongly and significantly fit to the empirically data.

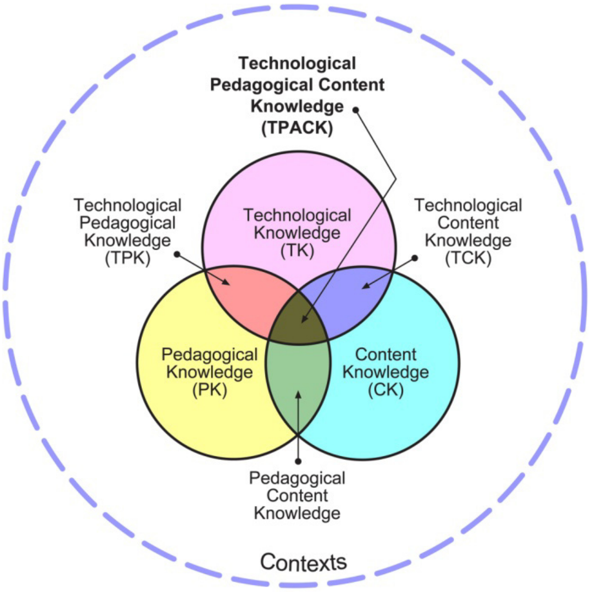

Figure 1A. TPACK framework

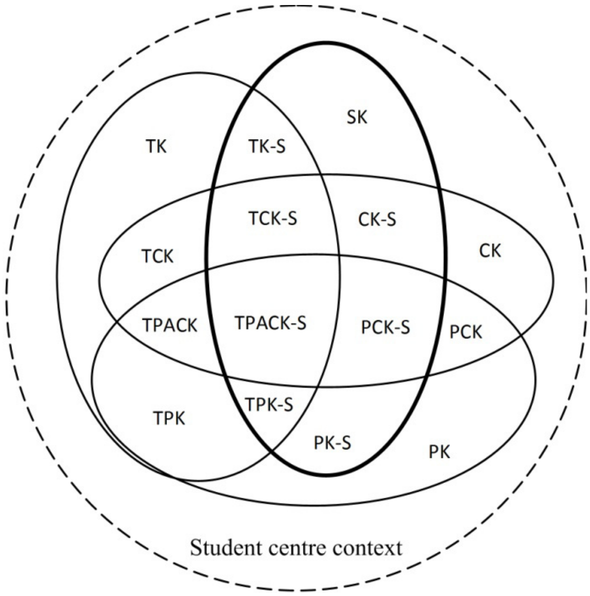

Figure 1B. TPACK-S framework

Note: SK = Student Knowledge, CK = Content Knowledge, PK = Pedagogical Knowledge, TK = Technological Knowledge, PCK = Pedagogical Content Knowledge, TCK = Technological Content Knowledge, TPK = Technological Pedagogical Knowledge, CK-S = Content Knowledge appropriate for instructing Student, PK-S = Pedagogical Knowledge appropriate for instructing Student, TK-S = Technological Knowledge appropriate for instructing Student, TPACK = Technological Pedagogical Content Knowledge, PCK-S = Pedagogical Content Knowledge appropriate for instructing Student, TCK-S = Technological Content Knowledge appropriate for instructing Student, TPK-S = Technological Pedagogical Knowledge appropriate for instructing Student, TPACK-S = Technological Pedagogical Content Knowledge appropriate for instructing Student

The idea of applying the TPACK framework to the practical program in teacher education has inspired us for further extending the TPACK model. As the Thai Educational Reform Act, 1999 has focused on "student-centre instruction", we have decided to add one more component of the *Student Knowledge* (SK) referring to knowledge concerning the students in term of their learning readiness and needs, and the integrated component with the existing seven component of the TPACK model. Based on the TPACK model development by Mishra and Koehler (2006), we proposed the extended TPACK model, or the TPACK-S model the teacher should have in order to transfer required knowledge appropriate for instructing students individually. Hence, our proposed extended model consisting of four main components of TK, PK, CK, and SK; and eleven integrated components of the four original

TPK, TCK, PCK, TPACK components, and the new seven integrated components of the Content Knowledge appropriate for instructing Student (CK-S), Pedagogical Knowledge appropriate for instructing Student (PK-S), Technological Knowledge appropriate for instructing Student (TK-S), Pedagogical Content Knowledge appropriate for instructing Student (PCK-S), Technological Content Knowledge appropriate for instructing Student (TCK-S), Technological Pedagogical Knowledge appropriate for instructing Student (TPK-S), and Technological Pedagogical Content Knowledge appropriate for instructing Student (TPACK-S) (see Figure 1B). There were two points worth mentioning, firstly, the initial model name was the S-TPACK, and had been revised using Mishra's abbreviation style as TPACSK, and finally fixed as TPACK-S which represented the true meaning of the model. The second one was the combination of the 15 components into 4 constructs of SK, TK, PK, and CK; we decided to employed Smith and Ragan (1999); Dever and Hobbs (2000); Cheng, Moc and Tsui (2001) which emphasized the technological and pedagogical knowledge sufficient to apply to the selected content for instructing the students based on the student-centre principle. As a result, our model contained one component in SK, two components in CK, four components in PK and 8 components in TK constructs. This TPACK-S Framework should help developing the essential qualities of teacher knowledge that they should have learned in order to be an effective instructor in developing, adapting, and applying the technological and pedagogical knowledge necessary for instructing the selected content to the students individually and improving their learning relevant to their readiness and needs.

2. Research Methodology

2.1. Participants

Participants consisted of 135 pre-service teachers in academic year 2012 from the Faculty of Education, Bangkaen and Kamphaengsaen campuses, Kasetsart University, which was randomly selected from public universities in Bangkok

2.2 Research Instrument

The data was gathered through the TPACK-S survey questionnaire. The questionnaire composed of 180 items on the pre-service teachers' knowledge in instruction, the 15 components of which used a Like-type scale with five response choices: "1 = strongly disagree," "2 = disagree," "3 = neither agree nor disagree," "4 = agree," and "5 = strongly agree. "Cranach's alpha coefficient reliabilities of all 15 components ranged from .699 to .905 (see Table 1) indicating highly reliable instruments.

2.3 Data Analysis

To analyze the data, first a descriptive statistics was used to present the means and standard deviations. Second, confirmatory factor analysis was used to validate the TPACK-S measurement model.

3. Result

The correlation matrix indicated that there were quite strong positive and significant correlations among all 15 components, with the correlation coefficients ranging from .201 to .937, as shown in Table 1. The 15 measures of sampling adequacy on the diagonal of the matrix ranged from .834 to .971, all of which were greater than the criteria of 0.600 confirming that the 15 components were highly correlated (Hair, et al., 2010). The results were confirmed by the overall measure of sampling adequacy of .935, Bartlett's test of sphere city = 2680.102, p = .000 indicating that the correlation matrix was far from equivalence with an identity matrix, which confirmed the strong relationship among all 15 components.

The confirmatory factor analysis results indicated that the hypothesized measurement model of TPACK-S was fit to the empirical data with Chi-Square = 64.743, df = 60, P = .315, RMSEA= .024, GFI = .939, AGFI = .879, RMR = .010, CFI = .999, NNFI = .998, all of these statistics meet the criteria set by Hair, et al. (2010). All variables in the first order confirmatory factor analysis had positive and significant loadings, ranging from 0.81 to 1.00 which signified strong weights of each indictor in the model. The SKC factor was measured only by one indicator SK with factor loading of 1.00 implying quite strong reliability measured of this factor. Considering CKC factor, the indicator having the highest factor loading was CK-S (.92). On the contrary, the two indicators of the PKC factor had quite similar factor loading with PCK (.89) and PCK-S (.89). For TKC factor, the indicator having the highest factor loading was TPACK (.98). The second order confirmatory analysis in TPACK-S Factor, the indicator highest factor loading variable was PKC (.97), followed by CKC (.72), TKC (.72) and SKC (.39), as shown in Table 2 and Figure 2. The correlation matrix indicated that there were quite strong positive and significant correlations among all 5 constructs, with the correlation coefficients ranging from .281 to .986 (see Table 2).

Table 1. Correlation matrix, means and standard deviations of S-TPACK or TPCASK's components

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SK	.834														
CK	.567**	.852													
CK-S	.627**	.719**	.918												
PK	.344**	.559**	.599**	.944											
PCK	.353**	.625**	.607**	.828**	.873										
PK-S	.421**	.468**	.555**	.765**	.762**	.933									
PCK-S	.347**	.476**	.553**	.740**	.830**	.782**	.930								
TK	.242**	.391**	.453**	.602**	.570**	.701**	.679**	.940							
TCK	.259**	.360**	.477**	.605**	.590**	.655**	.649**	.868**	.949						
TPK	.325**	.437**	.541**	.660**	.654**	.663**	.723**	.855**	.884**	.960					
TK-S	.244**	.201*	.424**	.506**	.456**	.620**	.621**	.764**	.814**	.789**	.929				
TPACK	.268**	.326**	.463**	.589**	.515**	.660**	.616**	.873**	.905**	.868**	.899**	.939			
TCK-S	.279**	.356**	.473**	.604**	.553**	.651**	.659**	.850**	.918**	.895**	.844**	.900**	.955		
TPK-S	.298**	.298**	.473**	.590**	.543**	.671**	.672**	.812**	.876**	.856**	.920**	.915**	.898**	.960	
TPACK-S	.310**	.330**	.488**	.591**	.540**	.680**	.656**	.843**	.888**	.865**	.894**	.937**	.888**	.920**	.971
Mean	3.174	3.315	3.217	3.265	3.362	3.267	3.281	3.227	3.199	3.228	3.096	3.166	3.177	3.128	3.168
SD	0.506	0.454	0.426	0.459	0.471	0.479	0.419	0.515	0.544	0.516	0.618	0.563	0.555	0.597	0.567
Reliability	0.743	0.799	0.699	0.762	0.855	0.814	0.776	0.827	0.899	0.871	0.905	0.879	0.890	0.887	0.851

Note: 1) **p<.01 *p<.05

2) Bartlett's Test of Spheri city = 2680.102 KMO Measure of Sampling Adequacy. = .935, df = 105, p = .000

3) Diagonal elements are KMO Measure of Sampling Adequacy for each variable.

4) SK = Student Knowledge, CK = Content Knowledge, PK = Pedagogical Knowledge, TK = Technological Knowledge, PCK = Pedagogical Content Knowledge, TCK = Technological Content Knowledge, TPK = Technological Pedagogical Knowledge, CK-S = Content Knowledge appropriate for instructing Student, PK-S = Pedagogical Knowledge appropriate for instructing Student, TK-S = Technological Knowledge appropriate for instructing Student, TPACK = Technological Pedagogical Content Knowledge, PCK-S = Pedagogical Content Knowledge appropriate for instructing Student, TCK-S = Technological Content Knowledge appropriate for instructing Student, TPK-S = Technological Pedagogical Knowledge appropriate for instructing Student, TPACK-S = Technological Pedagogical Content Knowledge appropriate for instructing Student

Table 2. Factor loading and Correlation matrix of TPACK-S measurement model

Variable	Factor Loading												R square
	SKC			CKC			PKC			TKC			
	Beta	b(SE)	FS	Beta	b(SE)	FS	Beta	b(SE)	FS	Beta	b(SE)	FS	
SK	1.00	1.00	1.57	-	-	-	-	-	-	-	-	-	1.000
CK	-	-	-	.81	.37	1.17	-	-	-	-	-	-	0.655
CK-S	-	-	-	.92**	.40(.04)	1.88	-	-	-	-	-	-	0.845
PK	-	-	-	-	-	-	.90	.41	.68	-	-	-	0.803
PCK	-	-	-	-	-	-	.89**	.42(.03)	.33	-	-	-	0.796
PK-S	-	-	-	-	-	-	.86**	.42(.03)	.43	-	-	-	0.732
PCK-S	-	-	-	-	-	-	.89**	.37(.03)	.70	-	-	-	0.791
TK	-	-	-	-	-	-	-	-	-	.91	.47	.29	0.823
TCK	-	-	-	-	-	-	-	-	-	.95**	.53(.03)	.48	0.902
TPK	-	-	-	-	-	-	-	-	-	.94**	.50(.02)	.55	0.889
TK-S	-	-	-	-	-	-	-	-	-	.94**	.58(.04)	.63	0.880
TPACK	-	-	-	-	-	-	-	-	-	.98**	.54(.03)	-.06	0.917
TCK-S	-	-	-	-	-	-	-	-	-	.95**	.53(.03)	-.03	0.893

TPK-S	-	-	-	-	-	-	-	-	-	.96**	.57(.03)	.31	0.919
TPACK-S	-	-	-	-	-	-	-	-	-	.94**	.53(.03)	-.23	0.874

Traits	Factor loading of TPACK-S Constructs	
	Beta	b(SE)
SKC	.39**	.12(.05)
CKC	.72**	.72(.10)
PKC	.97**	.97(.09)
TKC	.72**	.72(.09)

x^2= 64.743; df = 60; p-value = .315; RMSEA = .0243; GFI = .939; AGFI = .879; RMR = .010; CFI = .999; NNFI = .998

Correlation Matrix	1	2	3	4	5
Traits					
SKC	1.000				
CKC	.281	1.000			
PKC	.383	.712	1.000		
TKC	.281	.522	.713	1.000	
TPACK-SC	.389	.722	.986	.723	1.000

Note: **p<.01 *p<.05

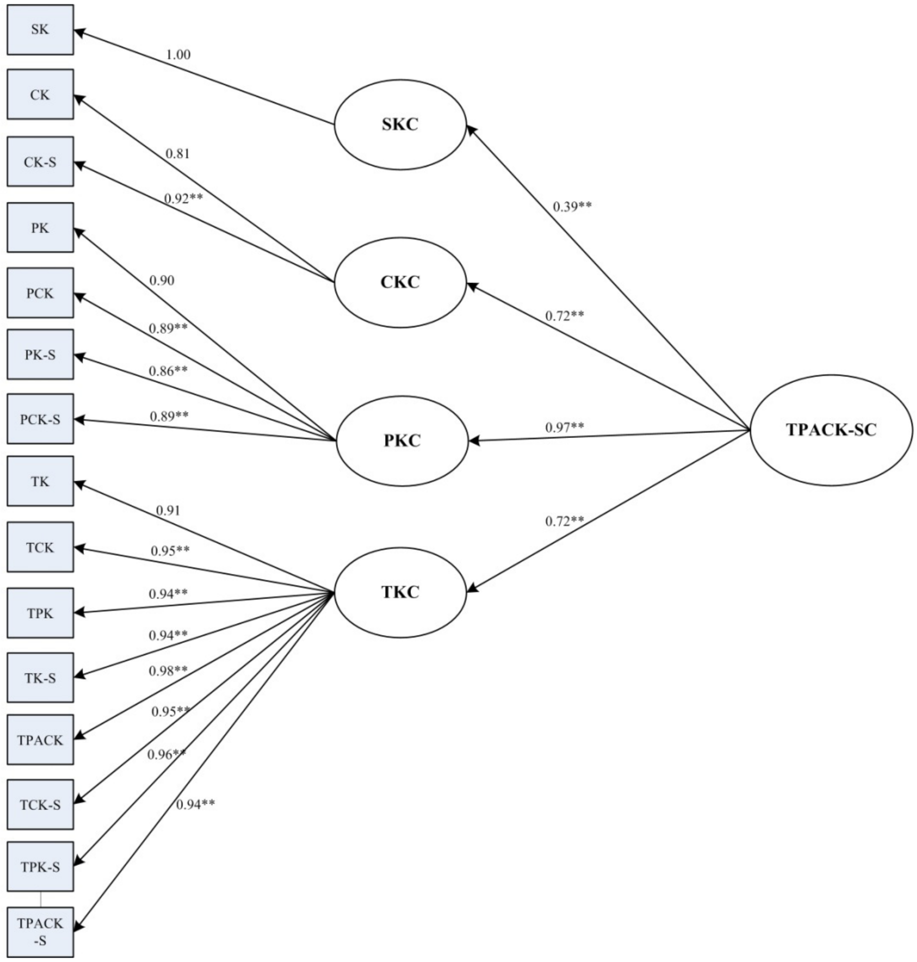

Figure2. The measurement model of TPACK-S from a confirmatory factor analysis

4. Conclusion and Discussion

Overall, the analysis results suggested four conclusions. *Firstly,* the confirmatory factor measurement model of TPACK-S was strongly and significantly fit to the empirically data, with each observed component showed high indices of consistency as judged by the experts and significantly high reliability measures. Comparing this model to the measurement model developed by Archambault and Barnett (2010), Lux (2011), Koehler, et al. (2011), and Lee and Tsai (2010), the result of which indicated that there were three, six and five indicators measuring TPACK, it could be seen that this study yielded more accurate result because of the confirmatory analysis used to validate the TPACK-S measurement model. The study results then gave strong support in confirming the validation of the TPACK framework created by Mishra and Koehler (2006). *Secondly,* judging from the factor loadings of the four constructs, it was perfectly in accord with our hypothetical proposition in terms of great importance of the three constructs in consecutive order of loadings: PKC (.97), TKC (.72), and CKC (.72), but unexpectedly contradicted to the SKC construct with rather moderate loading of only .39. The small loading of the SKC construct offered two issues for further support from empirical study whether it had been the outcome due to the insufficient training of the student knowledge construct in the teacher training program or the teacher students' inabilities to transfer the theoretical student knowledge into practice, or the disadvantages of this SKC construct on its only one component. *Thirdly*, the coefficient of determination for each of the components, known as construct reliabilities (Joreskog and Sorbom, 1996) ranged from 0.655 to 1.00 which indicated quite satisfactory results. *Finally*, considering the loadings of the fifteen components into the four constructs, the eight components of the TKC, the four components of the PKC, the two components of the CKC as well as the one component of the SKC showed very high loadings.

What we had learned from our empirical study to validate the TPACK-S framework which had been extended from Mishra and Kohler's (2006) TPACK framework, had indicated the three following arguments. *Firstly*, the TPACK framework had been intentionally created to display the significant role of technological knowledge (TK) as the important core component of the knowledge that the efficient teacher should have in order to deliver the effective teaching (PK) of the selected subject matter (CK). Similarly, our TPACK-S framework aimed to extend the effective role of TPACK framework for the efficient teachers to focus their role on students. The question had emerged concerning the significant role of the TPACK construct in the TPACK-S model, because the TPACK had been attenuated into only an observed component in the TPACK-S model. Consequently, this TPACK-S model has not been perfect and required further modification. *Secondly*, the measurement of the SK component in our model was not satisfied with an ideal measure, because we did not include sufficient teacher role concerning the class and student management part. With only one component for the SKC construct, there should be more items on measuring the teacher behaviour on student management, the result of which would increase the factor loading of this construct in the TPACK-S model. *Finally*, for the implication, our study had limitation about gathering data only from the student teachers in the pre-service teacher training program because we aimed to derive the insufficient area of training that could be improved and promoted. Following this study, we planned to continue our investigation on the in-service teachers in order to obtain the policy guidelines to improve teacher education curriculum.

In conclusion, we had confirmed the conceptualization of the TPACK model as well as the TPACK-S model, and empirically confirmed the significant role of the TPACK-S model but not the TPACK model which would be further studied. This study, in terms of the research implication, could be said to mark the beginning of the construction and the development of the reliable and valid measurement model of the TPACK-S model for the measurement of an effective teacher' knowledge. Further studies were necessary to obtain the standards and norms, to diagnose the teachers' weak-points in their knowledge and to improve them as well as to strengthen their strong-points, all of these efforts would help increasing student learning and achievement.

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