Exploring the profiles of pre-service teachers technological pedagogical content knowledge (TPACK) on earth and space science offline and online course

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Abstract: This study reveals the comparison of the TPACK profiles of pre-service elementary school teachers in the Earth and Space Science (ESS) offline and online lectures. The sample consisted of 97 students who took offline lectures in the 2018/2019 academic year and 85 students who took online lectures in the 2019/2020 academic year. The research instrument consisted of 38 questionnaire items that assessed the self-efficacy of the TPACK-21 components. The correlation analysis results show that in all aspects of basic knowledge and secondary knowledge, ESS online courses provide better results in developing TPACK abilities than offline courses. However, the SEM analysis results show that the structure of the TPACK ability development model in the offline class appears to be more stable than the online class. This indicates a need for further development in online learning strategies and approaches to lead to a more significant contribution to the development of TPACK.

Keywords: Earth and space science, online course, TPACK.

INTRODUCTION

Teacher education has the challenge of equipping the student's various skills in the classroom by utilizing technological resources. Without provision of the ability to integrate ICT in prospective teachers' educational process, when the teacher plunges into the real education environment in schools, their competencies will be left behind and unable to answer the various challenges of technological advancement in the future. ICT literacy is very important in learning, students and teachers must engage with various of learning technologies efficiently and effectively to achieve learning goals. One approach that can be taken is to design lectures that contribute to the development of TPACK for pre-service teachers.

The Primary School Teacher Education study program has the responsibility to produce primary school teacher graduates who can answer the challenges of integrating ICT into the learning process. Students who are at the primary school level are children born in the post-millennial era who are very familiar with various internet technologies and devices; integrating ICT into learning in primary schools has excellence potential to improve the quality of learning. One way that teacher education can be carried out is by organizing lecture programs that can equip the ability to integrate technology into learning. One of the learning approaches that can be used is through the TPACK framework which focuses on integrating technology, pedagogy and content in learning. This approach requires teachers to be able to use technology to create a learning environment but still pay attention to the pedagogy inherent in the learning content (Koehler & Mishra, 2009)

Research on TPACK has been carried out by several international researchers on several different material contents, for example on science learning (Canbazoglu Bilici et al., 2016; Jang & Tsai, 2012; Maeng et al., 2013), mathematics (Cuhadar, 2018; Jang & Tsai, 2012), economics (Raman, 2014) and English (Baser et al., 2016). In Indonesia, TPACK measurements that have been carried out include physics (Sholihah et al., 2016), biology (Sukaesih et al., 2017) and mathematics (Listiawan, 2020). In general, TPACK measurement can be done in several ways, such as measuring self-reports, open questionnaires, performance appraisals, interviews and observations (Abbitt, 2011; Koehler et al., 2013).

In this study, prospective teachers' TPACK profile will be explored through the analysis of the Structural Equation Model (SEM). To date, there are only a few studies that can map the relationship between the seven factors making up TPACK through structural equation modelling (SEM) (Chai et al., 2013; Koh et al., 2013). The relationship of each factor of the TPACK construct elements can predict a higher form of the TPACK construct (Mishra & Koehler, 2006). Several studies have mapped the relationship between the seven factors that make up TPACK; for example, the results of research in Singapore reported that among in-service teachers, CK and PCK did not predict teacher TPACK positively, while other factors predicted TPACK positively (Koh et al., 2013). Then, the results of research on Asian pre-service teachers show that the direct positive predictors of pre-service teacher TPACK are TCK, PCK and TPK, with TK, CK, and PK only having an indirect effect (Chai et al., 2013). Finally, research on pre-service teachers and in-service teachers in China, both PK, CK, TK and PCK did not predict TPACK positively (Dong et al., 2015). Based on these studies, it can be concluded that the profiles of TPACK under various conditions may not be the same, which implies that teacher educators need to understand the distinguishing effect of TPACK development on different groups of pre-service and in-service teachers to address their TPACK development needs specifically. The ESS course is one of the science courses held in the UHAMKA Primary School Education study program. Because in this course there are many discussed abstract concepts regarding natural phenomena that are difficult to observe directly, so the use of technology is involved in many ESS learning, so this course has great potential to then

provide the development of TPACK needed by prospective teachers. Based on this, in the 2018/2019 academic year, the TPACK approach began to be carried out in face-to-face lectures. However, in the 2019/2020 academic year, the ESS lecture process changed to online lectures, so that some adjustments were made in the use of the TPACK approach in lectures. The current study aims to understand pre-service teachers' TPACK profile after taking ESS courses offline and online. Comparing of the two types of lectures in building TPACK profiles of elementary school teacher candidates is carried out to understand how different lecture approaches will produce different TPACK profiles. Based on this, the research questions are: (1) What is the TPACK pre-service teacher profile after taking ESS offline lectures? (2) What is the TPACK profile of prospective teachers after taking ESS online lectures? (3) How is the difference between the TPACK profiles of pre-service ESS teachers between offline classes and online classes?

Technological Pedagogical Content Knowledge (TPACK)

TPACK is a basic framework that is effectively used in learning involving technology. The TPACK framework is used for learning that requires an understanding of the conceptual representation using technology; pedagogical techniques that constructively use technology to teach content; knowledge of what makes learning concepts difficult or easy and how technology can solve some of the problems that are on the student list; knowledge of the student's previous knowledge and theory of epistemology; and knowledge of how technology can be used to build on existing knowledge and to develop new epistemologies or to undermine old epistemologies (Mishra & Koehler, 2006). TPACK is a strategic way of thinking to plan and organize content by analyzing student needs and specific classroom situations, considering the potential that twenty-first-century technology can have to support student learning (Niess, 2008). From the definition above, it can be seen that the TPACK framework emphasizes the integration of technology, pedagogy and content in learning. TPACK provides a direction for a teacher to be able to integrate technology into learning. In this approach, teachers must be able to utilize technology to create a learning environment but still pay attention to the pedagogy inherent in learning content when the material is delivered to students.

TPACK consists of three main components, namely: technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (Koehler et al., 2013). The interaction of the three forms of knowledge will develop secondary forms of knowledge, which include knowledge of pedagogical content (PCK), pedagogical knowledge of technology (TPK), knowledge of technology content (TCK) and finally, the synthesis of these three forms of secondary knowledge will form TPACK (Dong et al., 2015). PCK is a unique form of teacher knowledge that synthesizes teacher PK and CK to help students bridge difficulties in mastering subject matter (Shulman, 1986, 1987). Correspondingly, TPK is a unique form of PK associated with the use of a particular technology, whereas TCK refers to technologically represented content knowledge which is not created for a purpose. Finally, TPACK refers to an integrated form of knowledge that can be created through a different combination of the previously discussed forms of knowledge (Cox & Graham, 2009). This form of knowledge is created through teachers or educational technology experts' design efforts when they build new practices to integrate ICT into classroom management (Tsai et al., 2013).

Technology integration into learning can be done by using websites, applications, and other tools to support a better learning process (Taghizadeh & Hasani Yourdshahi, 2020). Several researchers have reported the effectiveness of using technology that can be used in the application of the TPACK approach in learning, such as the use of interactive learning videos (Otrel-cass et al., 2012), Digital game-based learning (Hsu et al., 2017) and interactive presentation software (Galanti et al., 2020). The choice of the type of technology that will be integrated into the learning process is influenced by the learning context and the owned technological resources.

Characteristics of Earth and Space Science (ESS) Lecture in Primary School Teacher Education study program

The ESS is one of the Natural Sciences group courses, which is held in the UHAMKA Primary School Teacher Education study program. The main objective of holding this course is to provide a comprehensive understanding of the concept of ESS, which is one of the science sub-materials that are also taught in elementary schools. This lecture discussed the basic concepts of space including galaxies, stars, planets, satellites, comets, asteroids, other celestial bodies and the phenomena associated with them. It also discusses basic knowledge of the earth, including the lithosphere, hydrosphere and atmosphere, natural resources in the earth and the potential for natural disasters and their countermeasures.

Because in this course, there are many discussed concepts related to natural phenomena in real conditions. Those phenomena are difficult to find directly (both because of the cycle time constraints of the appearance of these phenomena and due to limited observation distances). Also, in ESS learning many simulation videos are used, animation, computer modelling and others to study natural phenomena, included in Earth and Space studies. With a lecture system that involves much technology, this course is very potential to equip the development of TPACK as shown in **Figure 1**.
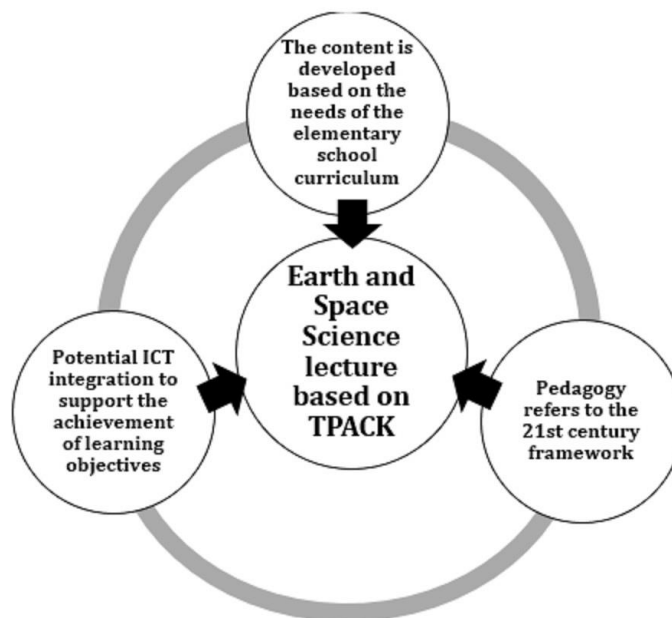

FIGURE 1. *The ESS lecture implementation scheme to develop TPACK*

In the Primary School Teacher Education study program, ESS courses are usually carried out offline with several focus activities: (1) students analyze the content of ESS suitable for teaching at the elementary level; (2) students compile a learning plan involving pedagogical knowledge and technology; (3) students carry out micro-teaching to simulate the learning plans they have made; (4) lecturers and other students provide criticism and suggestions on integrating of content, pedagogy and technology displayed by students in microteaching.

In semester 2 of the 2019/2020 academic year, online learning is applied to all courses including ESS. Based on this, the researcher feels the need to conduct research to compare whether there are differences in TPACK development profiles in offline and online ESS courses in the hope of getting enough references to develop online ESS learning so that it still contributes to the development of TPACK as is usually done in offline learning.

METHODS

The research design used in this study was a survey research design. The survey research design is a quantitative research procedure that is carried out to describe the attitudes, behavior, and characteristics of the population obtained through the sample population. The type of survey used is cross-sectional Group Comparisons design, a research design that collects data at one time for two sample groups to be compared (Creswell, 2012). In this study, the behavior to be measured and compared was the TPACK profile of Primary School Teacher Education students after taking ESS lectures offline and online.

Eighteen hypotheses will be tested through SEM analysis both on the offline and online course samples for later comparisons between the two samples. Twelve hypotheses are direct while the other six hypotheses are indirect hypotheses, as shown in **Figure 2**.
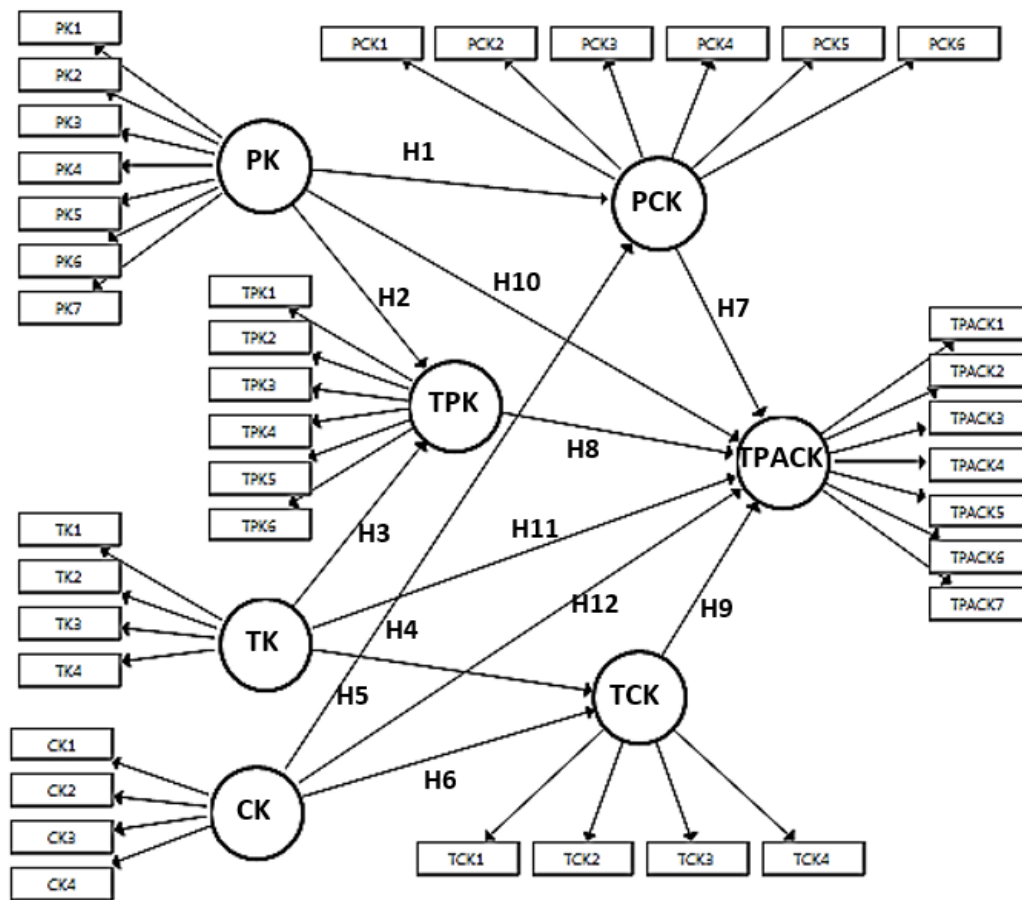
FIGURE 2. H*ypotheses model*

Participants

The sample of this research was all students of the Primary School Teacher Education Study Program, Faculty of Teacher and Education, Muhammadiyah University of Prof. Dr. Hamka, who attended lectures on basic concepts of earth and space, which consisted of 97 students who took offline lectures in the 2018/2019 academic year and 85 students who took online lectures in the 2019/2020 academic year.

Measures

In this study, an instrument in the form of a self-assessment questionnaire was used to explore the components of TPACK-21 (Valtonen et al., 2017), which consisted of Pedagogical Knowledge (PK), Technological Knowledge (TK), Content Knowledge (CK), Pedagogical Content Knowledge (PCK), Technological Pedagogical Knowledge (TPK). Technological Content Knowledge (TCK) and Technological Pedagogical Content Knowledge (TPACK). The seven variables are then broken down into 38 items of the self-assessment questionnaire using a Likert scale 1-6 as shown in **Table 1.**

TABLE 1. *Research variable indicators*

Variable	Item Code	Item
Pedagogical Knowledge (PK)	PK1	Learning strategies to guide students in group discussions
	PK2	Learning strategies to train students' critical thinking skills
	PK3	Learning strategies that can guide students to learn independently
	PK4	Learning strategies that can practice students' reflective thinking skills
	PK5	Learning strategies that can motivate students to convey ideas and ideas
	PK6	Learning strategies that can practice student problem solving skills
	PK7	Learning strategies that can train students' creative skills
Technological Knowledge (TK)	TK1	Using the right technology to solve problems in everyday life
	TK2	Understanding the development of new technology and its features
	TK3	Using word processing applications, images, videos and animations
	TK4	Using new technology tools (computers, gadgets, cameras, etc.)
Content Knowledge (CK)	CK1	Mastery of knowledge to develop science content
	CK2	Mastery of basic science theories and concepts
	CK3	Knowledge of the history and development of important theories in science
	CK4	Knowledge of the latest research in science
Pedagogical Content Knowledge (PCK)	PCK1	Knowing strategies in science learning that can guide students in group problem solving (2-5 students)
	PCK2	Knowing strategies in science learning that can guide students' critical thinking
	PCK3	Knowing strategies in science learning that can guide students to take advantage of the results of thoughts and ideas obtained from group discussions.
	PCK4	Knowing strategies in science learning that can guide students' reflective thinking
	PCK5	Knowing strategies in science learning that can guide students in planning independent learning
	PCK6	Knowing strategies in science learning that can guide students' creative thinking.
Technological Pedagogical Knowledge (TPK)	TPK1	Using ICT in learning as a medium for students' reflective thinking
	TPK2	Using ICT in learning as a medium for students to learn independently
	TPK3	Using ICT in learning as a medium for students to share ideas and thoughts together
	TPK4	Using ICT in learning as a medium for students' creative thinking
	TPK5	Using ICT in learning as a medium for solving student problems in groups (2-5 students)
	TPK6	Using ICT in learning as a medium for students' critical thinking
Technological Content Knowledge (TCK)	TCK1	Knowing the websites that contain online material for studying the science content
	TCK2	Knowing the ICT applications commonly used by science professionals

Variable	Item Code	Item
	TCK3	Finding out which ICT applications can be used to better understand science learning content
	TCK4	Knowing the technology that can be used to help describe difficult content in science
Technological Pedagogical Content Knowledge (TPACK)	TPACK1	Knowing how to use ICT in science learning as a tool to facilitate students to share ideas together
	TPACK2	Knowing how to use ICT in science learning as a tool to facilitate students so they can practice reflective thinking skills
	TPACK3	Knowing how to use ICT in science learning as a tool to facilitate students to learn independently
	TPACK4	Knowing how to use ICT in science learning as a tool to facilitate student problem solving activities in groups
	TPACK5	Know how to use ICT in science learning as a tool to facilitate students so they can practice creative thinking skills
	TPACK6	Knowing how to use ICT in science learning as a tool that can facilitate students to work in groups
	TPACK7	Knowing how to use ICT in science learning as a tool to facilitate students to practice critical thinking skills.

Data Analysis

PLS (Partial Least Squares) SEM-VB (Structural Equation Modeling-Variance Based) was used to test the research model using SmartPLS 3.0 software (Ringle et al., 2015). The main reason for choosing SEM as a statistical method for this research is because SEM offers simultaneous analysis and leads to more accurate predictions (Isaac et al., 2016, 2017a, 2017b).

RESULTS

Descriptive Statistics

The data that will be displayed in this descriptive statistic include the maximum score and minimum score, average, standard error, curriculum and skewness as shown in **Table 2**.

TABLE 2. *Descriptive Statistics (Offline Learning & Online Learning)*

	Type	N	Mean	SD	SE	t-value
PK	Offline Course	97	3.103	1.236	0.126	-3.037**
	Online Course	85	3.637	1.119	0.121	
TK	Offline Course	97	3.789	1.340	0.136	-1.756**
	Online Course	85	4.121	1.188	0.129	
CK	Offline Course	97	2.838	1.133	0.115	-6.387**
	Online Course	85	3.897	1.097	0.119	
PCK	Offline Course	97	2.950	1.131	0.115	-5.457**
	Online Course	85	3.843	1.067	0.116	
TPK	Offline Course	97	3.394	1.242	0.126	-2.540**
	Online Course	85	3.849	1.165	0.126	
TCK	Offline Course	97	2.992	1.213	0.123	-4.291**
	Online Course	85	3.732	1.098	0.119	
TPACK	Offline Course	97	3.127	1.176	0.119	-3.651**
	Online Course	85	3.758	1.150	0.125	

*Note: **p < 0.05*

Based on **Table 1**, it can be seen that all survey instrument items are normally distributed. This can be seen from the Kurtosis value which is in the range -7 to 7 and the Skewness value is in the range -2 to 2 (Curran et al., 1996; West et al., 1995).

Measurement Model

Confirmatory Factor Analysis (CFA) was used to test the construct validity, which consists of convergent validity and discriminant validity Convergent validity is a measure of the extent to which several specific construct variables gather together and share the same proportion to form high variance (Hair et al., 2014). In other words, convergent validity is a measure that shows that a set of indicators represents one latent variable. Convergent validity measures can be seen from the loading factor, average variance extracted (AVE), and composite reliability (CR), while the Discriminant validity measures include the Heterotrait-Monotrait ratio and Fornell & Larcker Criterion.

TABLE 3. *Convergent Validity*

	Type	Min	Max	Criterion
Loading Factor	Offline Course	0.719	0.929	> 0.7 (Kannan & Tan, 2005)
	Online Course	0.788	0.943	
Average Variance Extracted (AVE)	Offline Course	0.649	0.786	> 0.50 (Bagozzi & Yi, 1988; Fornell & Larcker, 1981; Hair et al., 2017)
	Online Course	0.712	0.846	
Composite Reliability (CR)	Offline Course	0.915	0.957	> 0,7 (Gefen et al., 2000; Kline, 2011; Werts et al., 1974)
	Online Course	0.937	0.974	

Based on the results of convergent validity analysis as shown in **table 3**, it can be seen that all indicators of convergent validity have been fulfilled because the automatic loading, AVE and CR values exceed all the parameters, so it can be concluded that all construct items are valid instruments in constructing each latent variable.

Apart from convergent validity, another measure that shows construct validity is discriminant validity. Discriminant validity is the extent to which a construct is entirely different from other constructs (Hair et al., 2010). Technically, discriminant validity requires that a construct is not highly correlated with other constructs (Campbell, 1960). Suppose discriminant validity is not seen as a construct measure condition In that case, there is a high correlation between the two variables, the researcher cannot confirm that the hypothesized structural pathway actually occurs or is simply the result of statistical differences (Farrell, 2010). Discriminant validity includes the Heterotrait-Monotrait ratio and Fornell & Larcker Criterion.

TABLE 4. *Discriminant validity: Heterotrait-Monotrait ratio (offline learning)*

	Type	CK	PCK	PK	TCK	TK	TPACK	TPK
CK	Offline Course							
	Online Course							
PCK	Offline Course	0.723						
	Online Course	0.790						
PK	Offline Course	0.757	0.803					
	Online Course	0.531	0.643					
TCK	Offline Course	0.717	0.595	0.531				
	Online Course	0.623	0.652	0.537				
TK	Offline Course	0.706	0.583	0.645	0.609			
	Online Course	0.667	0.744	0.551	0.540			
TPACK	Offline Course	0.791	0.806	0.766	0.809	0.706		
	Online Course	0.696	0.687	0.543	0.572	0.584		

	Type	CK	PCK	PK	TCK	TK	TPACK	TPK
TPK	Offline Course	0.706	0.723	0.680	0.651	0.806	0.848	
	Online Course	0.834	0.844	0.636	0.573	0.843	0.766	

The heterotrait-monotrait ratio's valueis the average correlation between heterotrait-heteromethod relative to the average monotrait-heteromethod correlation (Hair et al., 2017; Henseler et al., 2014). Based on **Table 4**, it appears that the Heterotrait-Monotrait ratio value is in the range 0.531 to 0.848, which is under the required criteria that the Heterotrait-Monotrait ratio value must be <0.85 (Kline, 2011).

TABLE 5. *Discriminant validity: Fornell & Larcker Criterion (offline learning)*

	CK	PCK	PK	TCK	TK	TPACK	TPK
CK	**0.855**						
PCK	0.661	**0.853**					
PK	0.683	0.738	**0.806**				
TCK	0.646	0.549	0.491	**0.872**			
TK	0.648	0.538	0.587	0.557	**0.886**		
TPACK	0.732	0.757	0.712	0.756	0.660	**0.874**	
TPK	0.652	0.677	0.630	0.605	0.749	0.802	**0.876**

TABLE 6. *Discriminant validity: Fornell & Larcker Criterion (online learning)*

	CK	PCK	PK	TCK	TK	TPACK	TPK
CK	**0.904**						
PCK	0.739	**0.878**					
PK	0.493	0.613	**0.844**				
TCK	0.574	0.607	0.493	**0.892**			
TK	0.615	0.689	0.511	0.495	**0.887**		
TPACK	0.662	0.660	0.526	0.540	0.552	**0.918**	
TPK	0.788	0.806	0.611	0.544	0.794	0.746	**0.920**

Table 5 and **table 6** show the Fornell & Larcker Criterion values where the thick diagonal values are the root of the AVE value, while the remainder is the correlation coefficient (r). Based on the Fornell & Larcker Criterion value, the condition for Discriminant Validity is when the latent variable's AVE square root value must be higher than the correlation between the latent variable and all other variables (Chin, 1998; Fornell & Larcker, 1981). Based on the values listed in **tables 5 and 6**, it appears that the root value of AVE (thick diagonal) shows a higher value than the other values for both the offline course and the online course, so it can be concluded that the discriminant validity for Fornell & Larcker Criterion has been fulfilled.

Based on the results of testing on all instruments used with Confirmatory Factor Analysis (CFA), found that all the required criteria for both convergent validity and discriminant validity were fulfilled. Therefore, it can be concluded that the instruments used in the study for both offline and online courses can be used to test the hypothesis of the model proposed.

Testing the Hypothesized Models

To test the hypothesized structural model, the standard values of beta (β) and t-values can be used through the bootstrap procedure with a 5,000 repeat sample (Hair et al., 2017). The structural model results based on the hypothesis are presented in **Figure 3** for the offline course and **Figure 4** for the online course. The path coefficients are summarized in **Table 7** for the offline course and **Table 8** for the online course.
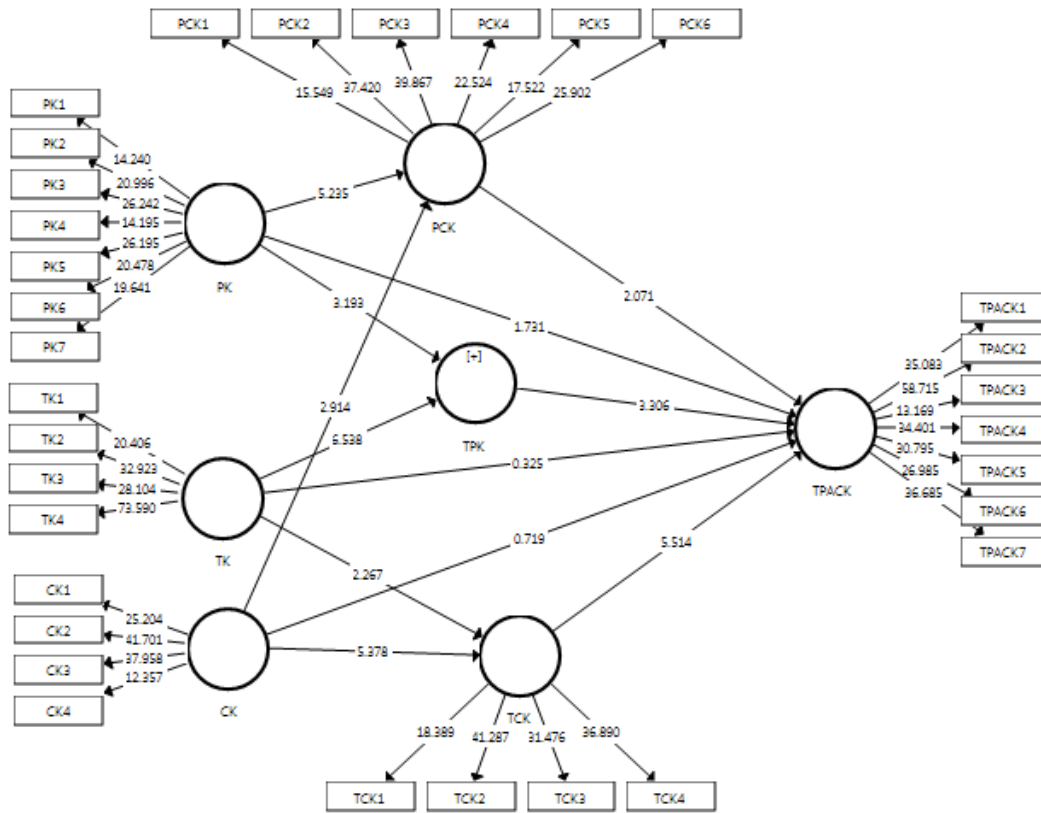
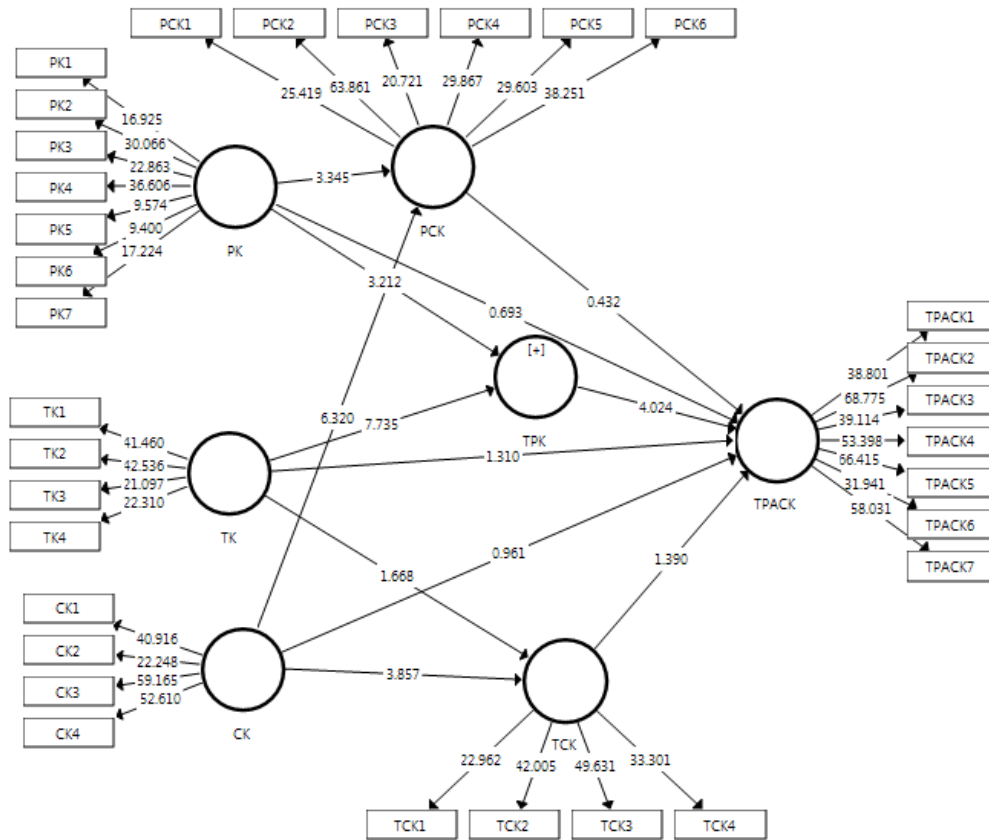**FIGURE 3.** *Structural Model Assessment (offline learning)*

FIGURE 4. *Structural Model Assessment (online learning)*

TABLE 7. *Structural model assessment (offline learning)*

Hypo-thesis	Path	STd. Beta	STd. Error	t-value	Bias	Conv.interval		Decision
						5.00%	95.00%	
H1	PK -> PCK	0.537	0.102	5.235	0.008	0.335	0.678	Supported
H2	PK -> TPK	0.290	0.091	3.193	0.004	0.145	0.436	Supported
H3	TK -> TPK	0.578	0.088	6.538	0.000	0.413	0.695	Supported
H4	TK -> TCK	0.238	0.105	2.267	0.007	0.052	0.401	Supported
H5	CK -> PCK	0.294	0.101	2.914	-0.009	0.157	0.485	Supported
H6	CK -> TCK	0.492	0.091	5.378	-0.005	0.317	0.630	Supported
H7	PCK -> TPACK	0.192	0.093	2.071	0.000	0.053	0.359	Supported
H8	TPK -> TPACK	0.344	0.104	3.306	0.000	0.165	0.497	Supported
H9	TCK -> TPACK	0.330	0.060	5.514	-0.003	0.234	0.433	Supported
H10	PK -> TPACK	0.151	0.087	1.731	-0.001	0.030	0.320	Supported
H11	TK -> TPACK	-0.027	0.083	0.325	-0.009	-0.167	0.097	not Supported
H12	CK -> TPACK	0.082	0.114	0.719	0.009	-0.103	0.273	not Supported
H13	PK -> PCK -> TPACK	0.103	0.058	1.776	0.002	0.029	0.216	Supported
H14	PK -> TPK -> TPACK	0.100	0.043	2.323	0.001	0.044	0.187	Supported
H15	TK -> TPK -> TPACK	0.199	0.071	2.792	0.001	0.096	0.322	Supported
H16	TK -> TCK -> TPACK	0.079	0.042	1.854	0.004	0.020	0.150	Supported
H17	CK -> PCK -> TPACK	0.056	0.033	1.691	-0.002	0.017	0.131	Supported
H18	CK -> TCK -> TPACK	0.162	0.036	4.547	-0.005	0.119	0.245	Supported

Note: p < 0.05

TABLE 8. *Structural Model Assessment (online learning)*

Hypo-thesis	Path	STd. Beta	STd. Error	t-value	Bias	Conv. interval		Decision
						5.00%	95.00%	
H1	CK -> PCK	0.577	0.091	6.320	-0.007	0.435	0.707	Supported
H2	CK -> TCK	0.433	0.112	3.857	0.007	0.203	0.590	Supported
H3	PK -> PCK	0.328	0.098	3.345	0.013	0.158	0.475	Supported
H4	PK -> TPK	0.278	0.086	3.212	0.015	0.144	0.413	Supported
H5	TK -> TPK	0.652	0.084	7.735	-0.015	0.510	0.771	Supported
H6	TK -> TCK	0.229	0.137	1.668	-0.003	-0.016	0.427	not Supported
H7	PCK -> TPACK	0.058	0.134	0.432	0.005	-0.139	0.302	not Supported
H8	TPK -> TPACK	0.597	0.148	4.024	-0.027	0.375	0.865	Supported
H9	TCK -> TPACK	0.151	0.109	1.390	0.009	0.003	0.369	Supported
H10	PK -> TPACK	0.067	0.097	0.693	-0.003	-0.102	0.211	not Supported
H11	TK -> TPACK	-0.143	0.109	1.310	0.007	-0.338	0.012	not Supported
H12	CK -> TPACK	0.117	0.122	0.961	0.003	-0.096	0.306	not Supported
H13	PK -> PCK -> TPACK	0.019	0.049	0.390	0.003	-0.043	0.120	not Supported
H14	PK -> TPK -> TPACK	0.166	0.064	2.597	0.000	0.079	0.297	Supported
H15	TK -> TPK -> TPACK	0.389	0.111	3.518	-0.025	0.249	0.629	Supported
H16	TK -> TCK -> TPACK	0.035	0.041	0.839	0.006	-0.002	0.130	not Supported
H17	CK -> PCK -> TPACK	0.033	0.079	0.420	0.005	-0.075	0.184	not Supported
H18	CK -> TCK -> TPACK	0.065	0.051	1.286	0.004	0.003	0.175	Supported

Note: p < 0.05

Figure 3 illustrates the path coefficient that significantly predicts the TPACK construction of pre-service teacher students on the offline course. The results showed that the level of basic skills consisting of PK, TK and CK significantly predicted towards the second level, namely PCK, TPK and TCK. Likewise, this level two ability has a significant prediction of TPACK's ability. Of the three direct lines that connect the basic skills of PK, TK and CK, only PK ability has a positive and significant direct effect on TPACK's ability, while the other two are not significant. These two basic abilities are only significant if through the level two abilities, namely PCK, TPK and TCK.

Figure 4 illustrates the path coefficient that significantly predicts the TPACK construction of pre-service teacher students on the online course. The results showed that

not all levels of basic skills in PK, TK and CK significantly had positive predictions for the second level, namely PCK, TPK and TCK. There is one basic ability, namely TK, which is not significant in predicting TCK abilities. Likewise at level two abilities (PCK, TPK and TCK), not all have significant predictions of TPACK's ability; only two abilities, namely TPK and TCK, can significantly predict TPACK's ability. The three direct lines connecting the basic skills of PK, TK and CK are all insignificant in predicting TPACK's ability, while the other two are not significant. The indirect path that connects basic capabilities and TPACK is only significant on the three lines.

DISCUSSION

This study shows that the seven-factor survey we adapted to measure the TPACK of student-teacher candidates both in offline and online classes has sufficient construct validity to be used to test hypotheses and the results of CFA with high reliability. This finding advances TPACK's research because it has strengthened the validation of previously developed instruments (Valtonen et al., 2017) to be applied to two different learning conditions: offline and online classes.

Table 2 provides the mean score and standard deviation for each factor measured in the two study groups. The TPACK construction in students who take online classes has higher scores in all aspects than the offline class with a significant difference based on the t-test results. In terms of the TPACK profile of prospective teachers, it can be seen that at the basic ability level, students perceive themselves to be the strongest in terms of kindergarten and the weakest in terms of CK. At the second ability level, students perceived themselves to be the strongest in terms of ROR and the weakest in terms of PCK. Both levels of ability affect the TPACK level of students both for offline classes and online classes. However, the level of student TPCK perceptions on all TPACK factors shows that both offline and online classes in ESS lectures do not have high effectiveness in developing TPACK. It seems necessary for lecturers who hold KDBA courses to continue to develop more effective learning strategies. Effectively integrating technology into the classroom requires teachers to have adequate pedagogical knowledge, content, and technology (Koh & Chai, 2016) and a careful examination of how technology, content, and pedagogy come together (Archambault & Barnett, 2010).

The differences between offline and online classes for all factors measured were significant. These results indicate that the learning strategies and approaches affect the mastery level of TPACK student teacher candidates. In the offline class that we do, the teaching practice is dominated by the teacher, so that there are very few aspects that support TPACK's ability. However, in online classes, the learning center is mostly with students, so that it is possible to develop TPACK aspects. Especially based on online media, students' ability to integrate students into content and pedagogy can be directly applied to technology. These results are in line with previous research, which states that in online learning, students can integrate content and pedagogy while leveraging technological capacities to build more authentic engagement opportunities than might be possible in face-to-face classrooms (Baker & Hjalmarson, 2019). In addition, in online learning, students can creatively take advantage of discipline-based content knowledge, pedagogical experiences, and new technology as they navigate synchronous video conferencing platforms (Galanti et al., 2020).

This study also found that in offline lectures TK and CK did not have predictions for TPACK, but the intermediary factors of PCK, TPK and TCK had directly affected TPACK and PK, TK, CK influenced TPACK through PCK, TPK and TCK. These results are partly consistent with Koh et al. (2013), who identified that CK had no significant effect on TPACK, and TPK and TCK were significant predictors of TPACK. However, other literature shows that PCK is an important factor in technology integration (Pamuk, 2012). As for online lectures, the three basic PK, TK and CK skills do not have a direct prediction of TPACK, while the intermediary factor of PCK has no prediction of TPACK. These results are

inconsistent with the findings which reported that TK, PK, and CK were significantly correlated with TPACK (Chai et al., 2010) but consistent with the findings of Koh et al. (2013), who identified that PCK had no significant effect on TPACK. This finding is also consistent with the Investigation of Dong, et.al. (2015) reported that PK, CK, TK and PCK did not predict TPACK positively. These results reinforce that the profiles of TPACK under various conditions may not be the same, which implies that teacher educators need to understand the distinguishing effects of TPACK development under various conditions.

When the two models are compared, the offline classroom model is more reflective of the theoretical model, while the online classroom model appears to be more fragmented. This is a reasonable result because KDBA lectures with offline lecture mode have been going on for a long time so that it is more established in developing learning strategies and approaches that have an impact on TPACK development while KDBA recovery with online recovery mode has only been carried out in the even semester of 2019/2020, so that requires further development in learning strategies and approaches in order to lead to a more significant contribution to the development of TPACK.

CONCLUSION

The main goal of this research is to compare the TPACK mastery profile of elementary school teacher candidates in the ESS course between students who take offline lectures and students who take online lectures in terms of each aspect of basic knowledge and secondary knowledge forming the TPACK structure and from the structural model prediction floating TPACK capabilities. The results show that in all aspects of basic knowledge and secondary knowledge, online ESS courses provide better results in developing TPACK abilities than offline ESS courses. However, the structure of the TPACK ability development model in the offline class that looks more established than the online class indicates that further development is needed in online learning strategies and approaches to make more significant contribution to the development of TPACK.

Although this study succeeded in providing an adequate comparison of the TPACK profile between offline class and online class, this study also has limitations in not revealing the differences in implementing offline learning and online learning, which might provide more comprehensive results in analyzing the advantages and disadvantages of each. Each mode of lecture in developing TPACK abilities of pre-service teacher students in ESS courses. In the future, further research needs to be carried out by exploring these things to provide further additions to the achievement of current research results.

However, despite the study's various limitations, this finding is quite encouraging, because it has succeeded in providing a comparative picture of TPACK's ability development profile from offline and online ESS lecture modes. The findings of this study can provide important insights for lecturers and policymakers on how to design better online ESS courses in supporting the development of TPACK.

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