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Effect of a Science-Based TPACK Program for Elementary Preservice Teachers According to Their Gender

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The study sought to analyze the effects of the Technology, Pedagogy, and Content Knowledge (TPACK) program on the relationship between preservice elementary school teachers (n = 194) and the variables of their gender. Quantitative data collected during the fall semesters of 2018 and 2019 were statistically analyzed using the Wilcoxon rank sum test to compare the teachers' attitudes toward convergence, TPACK, and science teaching efficacy beliefs according to group variables. The comparison of attitudes toward convergence indicated gender-specific differences in Year 1 in knowledge, personal relevance, social relevance, interest, and overall scores. No significant differences were found in most components in Year 2. The pre- and posttest TPACK results revealed significant gender-specific differences in Year 1 for Technological Knowledge (TK), Content Knowledge (CK) of Science, Content Knowledge of Korean, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge, TPACK, and overall scores. In Year 2, gender-specific differences were present in TK, CK of Mathematics, CK of Social studies, CK of Science, and TPACK. Analysis of Science Teaching Efficacy Belief Instrument (STEBI-B) by gender indicated that the overall scores and personal science teaching efficacy of female student teachers improved in Year 1. In Year 2, no significant gender-specific differences were found in the STEBI-B in the pre- and posttest results.

The advent of — and improved accessibility to — digital technology has raised interest in the knowledge required for teachers to be able to apply technologies effectively as classroom tools for teaching and learning (Colvin & Tomayko, 2015; Dong et al., 2020; Li et al., 2016; Pierson, 2014). Furthermore, researchers developed the field by introducing the Technology, Pedagogy, and Content Knowledge (TPACK) framework, which represents the knowledge needed by a teacher for effective pedagogical practice to integrate technology and technological content in the classroom (Bull et al., 2019; Mishra & Koehler, 2006; Niess, 2005). This framework aims to supply teacher training programs that instruct teaching methods using appropriate educational technologies.

TPACK also enables teachers, educators, and educational engineers to reevaluate the knowledge and utilization of technology and affects research areas related to technology (Koh et al., 2015; Park & Kang, 2014; Zhang et al., 2019). Although studies on the effects of the TPACK approach (Anderson et al., 2017; Chua & Jamil, 2014; Jaipal-Jamani & Figg, 2015) and factors related to improvements to TPACK for training preservice teachers (Cheng & Xie, 2018; Mai & Hamzah, 2016; Yeh et al., 2014) have been continually investigated, this study sought to examine both simultaneously. Through the combined perspective, teacher educators could have a comprehensive understanding of preservice teachers' TPACK and how to effectively convince them to integrate technology into their practice. In accordance with this objective, we reviewed the relevant literature about variables reported to affect preservice teachers' TPACK.

Literature Review

Effects of Reinforcing TPACK

TPACK reinforcement for preservice teachers provides effective instruction for teaching specific subjects in the fields of science, technology, engineering, and mathematics (STEM). Additionally, the process of reviewing knowledge may help teacher candidates develop high-order thinking that increases the proficiency in practical knowledge (Hofer et al., 2015; Yeh et al., 2014). The TPACK framework is useful in effectuating the vision of the International Society for Technology in Education (ISTE) and the National Council of Teachers of Mathematics (NCTM), which have affirmed that the appropriate use of technology can enhance the effectiveness of learning and inspire learner interest (NCTM, 2015; Harrington et al., 2019).

Hofer and Grandgenett (2012) also asserted that the improvements to TPACK must be deliberately diagnosed in preservice teacher training and, in that process, reflection and metacognition are required to better understand content knowledge, pedagogical knowledge, and technological knowledge, as well as knowledge about how they intersect. The TPACK framework enables teachers to implement flexibility and dynamic strategies which can, eventually, contribute to improving the quality of classes (Chua & Jamil, 2014; Yeh et al., 2014).

According to Shin (2013), who studied the impact of fixed mindsets on the TPACK of preservice teachers, the promotion of knowledge through practical experience is more important than definitional factors such as attitudes or beliefs. Moreover, digital natives perceive technology utilization as something that changes through effort and training, rather than reinforcing a fixed belief.

On the other hand, a previous study conducted by Jung (2013) analyzing individual teacher factors affecting the TPACK of elementary school teachers indicated that, although gender is a personal factor that exerts significant influence, effects are more dependent on psychological factors, such as educational beliefs, self-efficacy, and attitude. According to his study, the personal background was insignificant in explaining TPACK, but it is unclear whether these conditions also correspond to preservice teachers due to the differences such as years of teaching experience, pedagogical strategies, content knowledge, an age range, teaching environment for a lesson, and so forth.

Many studies have revealed that the actual use of technology in content-based instruction is influenced by teachers' perceptions and technostress (Dong et al., 2020; Jaipal-Jamani & Figg, 2015; Varol, 2015), as well as TPACK training in preservice teacher education (Anderson et al., 2017; Koh et al., 2015). Therefore, further research could be expanded and improved upon to account for regional, cultural, and classroom environmental differences, due to the attributes of TPACK that are generally affected by intrinsic factors including teacher motivation and beliefs.

Several current studies have found that when technologies, for example, web 2.0 tools represented in social media or learning management systems, are infused in teacher training, the online collaborative environment impacts outcomes of different years of experience and scores groups (Akyuz, 2018; Zhang et al., 2019). Such attention to tentative factors that influence the development of preservice teachers' TPACK while being engaged in teacher training with curriculum contents and standards can strengthen teacher educators' understanding of how they can be supported to respond to the demands of teaching STEM in a science classroom.

Descriptive Indicators of Teachers' TPACK

A teacher's beliefs, such as pedagogical philosophy, thinking on technology, motivation, or readiness, may influence technology integration (Howard et al., 2015; Yuan et al., 2019). For instance, Zhang et al., (2019) found a positive correlation between technology-integrated lesson planning based on teachers' TPACK and personal characteristics or academic performance in teacher education. Teachers' epistemic network characteristics could be also a significantly relevant factor.

Ertmer et al. (2007) proposed that exemplary technology-using teachers deemed inner drive and personal beliefs as the most interrelated factors to the success of technology-integrated lessons. According to them, the teaching experience and the gender of teachers can be considered influencing factors.

Because TPACK is an individual intrinsic indicator of the possible effect of decreasing teachers' technostress, it is necessary to facilitate more growth of TPACK of instructors through school support and self-efficacy enhancement (Dong et al., 2020). Yeh et al. (2014) tried to structuralize science teachers' TPACK using the framework comprising eight knowledge dimensions and 17 indicators. Notably among them, using information and communication technology (ICT) to understand subject content and using ICT representations to present instructional representations were pointed out as important for effective instruction of science content.

Despite the delineating indicators of teachers' TPACK that have been studied, we believe there is still a lack of given factors that affect preservice teachers' TPACK formation or reinforcement in empirical settings. This study examined how a relatively distinct variable of preservice teachers, in particular gender, differentiated their TPACK development to train science-teaching competencies. Understanding a predictable factor influencing the intention of preservice teachers to use educational technologies may contribute to the development of teacher preparation programs that can help them effectively use those materials (Li et al., 2016).

Attitude and Science Teaching Efficacy Perspective

Even though preservice teachers possess TPACK competencies, their attitudes regarding technology in education can considerably affect technology adoption in lessons (Varol, 2015). Involving positive and negative judgments that are constructed out of beliefs or experiences, attitudes indicate an intent of a person to carry out a specific behavior. Moreover, teachers' attitudes may allow one to predict whether teachers would be prone to incorporate technology-integrated strategies into classroom activities (Cullen & Greene, 2011; Dong et al., 2020).

According to a study investigating high school students' attitudes toward convergence (Sya'bandari et al., 2019), positive attitudes could help a person creatively solve intricate problems. Meanwhile, they demonstrated the significant differences of interest and self-efficacy between the groups divided into gender and high school track variables. Unlike the findings of Sya'bandari et al. (2019), Li et al. (2016) asserted that gender would not make a difference, although attitudes toward technology or technology efficacy were considered a possible indicator of technology adoption of preservice teachers. In the present study, we tried to ascertain the different changing degrees of attitudes toward convergence between male and female preservice teachers in the context of training for TPACK competencies.

The term self-efficacy refers to the depiction of individual confidence to successfully perform behaviors that ensure concomitant results (Bleicher, 2004; Hechter, 2011). The reason self-efficacy is crucial in teacher preparation is that highly self-efficacious teachers tend to comprehensively reflect science teaching plans, suitably reweave lessons, and practically indicate excellent instructional strategies for learners (Fazio et al., 2020; Kozcu Çakir, 2020). There have been efforts of educators who contribute to the belief that reformed teacher candidates' programs enhance preservice teachers' science teaching efficacy; for example, a teaching method course focused on the integration of science content knowledge and pedagogy was known as significantly effective to increase the efficacy of elementary school preservice teachers (Hechter, 2011; Kozcu Çakir, 2020).

Hughes (2013) also determined that teachers who have high levels of efficacy on digital technologies were more prone to apply technologies to their classrooms and more enthusiastic to practice a constructive pedagogical perspective. Such teaching efficacy can fundamentally help teachers overcome unexpected barriers when they encounter various problems during their integrated lessons encompassing plan, management, performance, and assessment (Ertmer et al., 2007).

Recent studies have found that an education course for the improvement of elementary preservice teachers' computational thinking positively impacted their self-efficacy, interest, and confidence within a technology-integrated approach such as coding, robotics, or gamification (Kaya et al., 2019; Mason & Rich, 2019; McGinnis et al., 2020; Yuan et al., 2019). Implications for teacher educators are that content-specific preservice teacher training should support their competencies and viewpoints to comprehend how to integrate technologies within and across disciplines (Suters, 2021). Accordingly, through integrated courses in teacher preparation, preservice teachers can improve their attitude toward convergence and convergent knowledge (Hughes, 2013; Kim & Jeon, 2016). Futher, they can gain self-trust that enables them to provide effective science lessons and facilitate learner achievement (Fazio et al., 2020; Hechter, 2011; Mason & Rich, 2019).

Effects of Gender on Preservice Teacher Education

The Teachers College, a representative organization for the training of elementary school teachers in South Korea, has a far greater number of female students than males. According to the OECD (2019), the number of men in teaching is low due to factors such as social perception or expectations for future earning potential. Hence, the proportion of elementary school female teachers reaches 78% in South Korea and 83% worldwide. However, gender imbalance in teaching positions can affect student achievement, student motivation, and teacher retention. Therefore, it is necessary to study the effects of gender differences in countries where low numbers of male teachers are trained (OECD, 2019).

A previous study that examined the factors by which gender variables affect education for preservice teachers mainly addressed the inevitable limitations of gender differences and how differences in gender-specific abilities were manifested. Gender variables of college students in teaching programs can affect their training and education due to past acquired gender roles, the process by which first-year college students select their instructors, and their experiences after entering the postsecondary level courses.

For example, in the admission process for teachers' colleges in South Korea, a gender selection quota is enforced by which one gender cannot exceed a certain percentage. Despite the principle of free competition, an assigned minimum number of male candidates must be selected in the admission procedure (Kim & Jeong, 1996). Brown and Silber (2000) also noted the importance of the values of education in overcoming gender, race, and class inequality, deeming that preservice teachers' recognition and mitigation of sexual inequality must presuppose a deep understanding of the effect of such inequality in teaching and learning. A study on science, technology, and social interactions among preservice and in-service teachers illustrated that men are perceived as having more realistic views enabling a rational understanding of the nature of science and technology and social interactions compared to women (Jo et al., 2000).

On the other hand, a measurement of ICT literacy skills among new students enrolled in teachers colleges demonstrated that female students scored higher, contrary to expectations that male students would score higher due to familiarity with areas such as computers and the internet (Noh et al., 2013). It would also be worthwhile to examine possible changes assuming an expansion of the study scope from freshmen to all students who have participated in the teachers college curricula.

Gender has been reported as a variable that can affect performance depending on the context of the tasks provided (Renninger et al., 2018). Regarding gender differences, previous studies brought up differences in the average levels of academic self-concept between males and females owing to dominant gender stereotypes (Espinoza & Taut, 2020). The gender stereotypes were derived from the cultural features of the society to prescribe amorphous perceived properties (Ergen et al., 2019). They also impacted a significant difference that was established in favor of males in the technological constructs of TPACK (Irmak & Tüzün, 2019), or in favor of females in terms of PK (Ergen et al., 2019).

Meanwhile, few researchers have indicated that gender cannot affect the TPACK efficacy of preservice teachers (Jang & Tsai, 2013; Karakaya & Yazici, 2017; Thinzarkyaw, 2020). Despite particularly examining the issue of gender in technology infusion for teaching, there have been no conclusive findings regarding the gender influence on the TPACK of preservice teachers (Yusuf et al., 2021), especially in the context Korean universities. Thus, investigating the effect of gender on the self-perceived TPACK of preservice teachers had the potential of providing information on whether a significant difference can be found in preservice teachers' TPACK and relevant improvement because of a static variable.

Research Questions

Calls have increased for further training opportunities through integrated teacher education programs for future preservice teachers to teach the natural sciences (Corlu et al., 2014). In the meantime, science education experts, in-service teachers, and preservice teachers positively view interdisciplinary integration by convergence, but concerns have also been raised about curricula that excessively emphasize integration (Son et al., 2014).

In particular, to promote integrated education, there have been calls for the development and distribution of integrated education programs, teacher training, distribution of various teaching and learning materials, teacher collaboration, and improvement of curricula (Geum & Bae, 2012). Elementary school teachers, however, are often insufficiently prepared to conduct integrated science teaching due to a lack of experience, knowledge, and self-confidence about STEM fields (McGinnis et al, 2020; Suters, 2021; Yuan et al., 2019). Preparations must begin at the preservice education stage to establish basic foundations for a more efficient approach to training competent preservice teachers.

Therefore, quantitative research is necessary to analyze the relevance of TPACK in specific subjects beyond the scope of measuring general class knowledge to determine the effectiveness of classes. Exploration of factors that may substantially affect TPACK, such as teaching immersion, class expertise, and teaching efficacy may also be necessary (So, 2013; Varol, 2015; Zhang et al., 2019).

Consequently, we sought to draw implications for fostering elementary school teachers in preparation for integrated education by analyzing the effectiveness of TPACK programs based on the gender of college students in teaching programs and determine a specific research question as follows:

How do the effects of a science-focused TPACK program vary for college students in teaching programs (Education majors) in terms of (a) the attitudes toward convergence, (b) technological pedagogical content knowledge, and (c) science teaching efficacy belief, depending on the gender?

Methods

Research Approaches

The objective of this study was to identify the effects of the TPACK program by gender for college students pursuing careers in Education who were taking courses on science education teaching methods for elementary school pupils. Using previously developed tools for the inspection of attitudes toward convergence, TPACK, and the Science Teaching Efficacy Belief Instrument (STEBI-B), we surveyed the self-evaluation of college students training to be teachers four times across two semesters, before and after an 8-week teacher education program based on the TPACK concept oriented toward science curricula (Choi & Hong, 2019), and the results were statistically analyzed. This study tried to provide materials to clarify the characteristics of the gender groups of teachers college students training to teach in the STEM fields.

Sample

The study participants were 194 third-year student teachers from a college in South Korea. They were all enrolled as student teachers for the fall terms of the 2018 and 2019 school years. All had completed a theoretical course on elementary science education and participated in a course on practical methods of science education.

In Year 1 (2018), the participants consisted of 20 males (21.1%) and 75 females (78.9%) for the pretest, and 24 (25.0%) males and 72 (75%) females for the posttest. In Year 2 (2019), there were 32 male students (32.3%) and 67 female students (67.7%) for the pretest, who had enrolled in the 2019 academic year and junior student teachers of the subject in the 2018 academic year, and 29 (29.6%) males and 69 (70.4%) females for the posttest.

Instructional Context of the TPACK program

The TPACK program for preservice elementary school teachers involved practical exercises applying acquired knowledge and practical tactics for their actual teaching and learning in the prospective science-based integrated classrooms. The elementary teacher preparation program comprised five learner activity-centered units. According to the TPACK development stages under learning activity types (LATs) by Hofer et al. (2015), they were engaged in the main assignment to plan an integrated lesson considering core concepts and contents of national science curricula. Lesson topics of the five units were (a) the theory and the procedure of the TPACK framework based on learning activity types, (b) organization of the science content-based STEM lessons, (c) lesson plan design based on the TPACK framework, (d) preparation for STEM lessons using the TPACK framework, and (e) practice and reflection on teaching with TPACK.

Lesson planning in the program followed these stages: (a) determining targeted learning standards and goals, (b) considering the classroom and school contexts, (c) choosing learning activity types and sequence, (d) making an assessment plan, and (e) selecting learning materials and aids. See Appendix A for course outline and sample materials.

To enhance STEM teaching practices of preservice teachers, an elementary teacher preparation program (Choi & Hong, 2019) that was developed on the basis of the TPACK concept (Mishra & Koehler, 2006) and the taxonomy of LATs (Hofer et al., 2015) was used. The science-based TPACK development program was designed to improve practical and professional strategies that maximize elementary school students' achievement, depending on planned science topics. It also offered opportunities for preservice elementary school teachers to determine how they adopt technologies at the right time and place based on their TPACK and how they reconstruct and implement inquiry-based, problem-solving science lessons.

We handed out workbooks that were made especially for the participants, and they executed the preservice teacher education program through face-to-face lectures, peer discussions, and an interactive online class (e.g., Google Classroom). In the program, we supported the engaged preservice teachers in their quest to inquire about educational technologies (e.g., Autodesk 123D, Scratch, and Time-lapse), understand science curricula, experience cooperative works, and improve problem-solving skills. Considering the importance of a visual representation of TPACK that helps teachers be aware of the TPACK model and their knowledge (Covlin & Tomayko, 2015), we asked the preservice teachers to reflect on and explain their TPACK using Venn diagrams before the teaching demonstration.

The preservice teachers' designing and demonstrating of learning activity planning guides were assigned and assessed. In the process of lessons creation, any biased content or methods toward a particular type of gender was not included.

Instruments

The areas investigated in this study were attitudes toward convergence and TPACK and beliefs about science teaching efficacy. The components, number of items, and sample statements for each test tool are presented in Table 1 (also in Appendix B, with a translated full copy of the questionnaires).

Table 1
The Instruments for Pretest and Posttest Regarding TPACK and Preservice Student Teachers

Measurement	Component	Number of Items	Examples
Attitude Toward Convergence (Shin et al., 2014)	Knowledge	4	- It is sufficient to solve problems using knowledge of various fields.
	Personal relevance	5	
	Social relevance	4	
	Interest	5	
	Self-efficacy	5	
Technological Pedagogical Content Knowledge (Schmidt et al., 2009)	Technological Knowledge	7	- I frequently use technologies in the daily routine. - I have various studying strategies to understand science concepts. - I choose technologies to increase the effects of pedagogical methods.
	Content Knowledge of Math	3	
	Content Knowledge of Social studies	3	
	Content Knowledge of Science	3	
	Content Knowledge of Literacy (Korean)	3	
	Pedagogical Knowledge	7	
	Pedagogical Content Knowledge	4	
	Technological Content Knowledge	4	
	Technological Pedagogical Knowledge	5	
	Technological Pedagogical Content Knowledge	8	
Science Teaching Efficacy Belief Instrument B (Enochs & Riggs, 1990)	Personal Science Teaching Efficacy	13	- When a student does better than usual in science, the learner improvement is often attributed to the teacher exerting extra effort.
	Science Teaching Outcome Expectancy	10	

In this study, the construct of attitudes toward convergence comprised five components: knowledge of convergence, personal relevance, social relevance, interest, and self-efficacy, as established by Shin et al. (2014). The attitude toward convergence has been found to demonstrate a causal relationship with scientific motivation. The internal reliability of the inspection tool was 0.87 for Knowledge (K), 0.91 for Personal Relevance (P), 0.90 for Social Relevance (S), 0.86 for Interest (I), and 0.86. for Self-efficacy (E).

As for the TPACK, the selected inspection tool was developed by Schmidt et al. (2009) and adapted by Shin (2013). It consists of TK, PK, CK, and their intersecting knowledge components, namely, PCK, TPK, TCK, and TPACK. Cronbach's α for this inspection tool was 0.86 for PK, 0.80 for CK, 0.84 for TK, 0.70 for PCK, 0.76 for TPK, 0.84 for TCK, and 0.89 for TPACK.

The STEBI-B by Enochs and Riggs (1990) for the measurement of science teaching efficacy beliefs includes Personal Science Teaching Efficiency (PSTE) and Science Teaching Outcome Expectancy (STOE). Cronbach's α is each 0.90 for PSTE and 0.76 for STOE.

Data Collection and Analysis

Data were collected via a written survey administered before and after the implementation of the TPACK program during the autumn semesters of 2018 and 2019. Except for the genders of the participants, the three surveys, which lasted total of 40 minutes, were conducted anonymously. Using the set of three instruments, we investigated their pretest responses on the first day of the TPACK program application, while the posttest was administered right after the end of the intervention. The pre- and posttest results were used for statistics after all the responses from each study participant on attitudes toward convergence, TPACK, and STEBI-B were scored.

The instrument items were scored using a 5-point Likert scale, ranging from 1 = *not at all* to 5 = *very much so*. The surveyed data were analyzed using IBM SPSS Statistics 26.0. The composition of the teachers college was not suitable for performing parametric statistics because the number of male students was significantly low. Hence, the pre- and posttest means were compared using the Mann–Whitney Wilcoxon test, which is also called the Wilcoxon rank sum test.

Research Results and Discussion

The findings in this article illustrated the comparison based on gender variable from perceived self-assessment in pre-and posttests in terms of three domains of attitudes toward convergence, TPACK, and science teaching efficacy beliefs. While most research regarding the significant differences between male and female prospective teachers at a certain point where they investigated the gender difference, this study focused on the effect of the gender variable during their improvement of those domains.

Attitudes Toward Convergence

The results of the Wilcoxon rank sum test performed on pre- and posttests on attitudes toward convergence after the application of the TPACK program in Years 1 and 2 are presented in Table 2. The components that demonstrated gender-specific differences before and after the application in Year 1 were Knowledge, Personal Relevance, Social Relevance, and Interest; there were also significant differences in overall scores.

Table 2
Wilcoxon Rank Sum Test Results on Attitude Toward Convergence in 2018 and 2019 to Compare Effects of Gender Variable

					Ranks			Test Statistics			
Component	Test	Gender	*M*	*SD*	*N*	Mean Rank	Sum of Ranks	Mann Whitney *U*	Wilcoxon *W*	*Z*	Asymp. Sig. (2-tailed)
2018											
Knowledge	Pre	M	3.5125	.76297	80	175.74	14059.50	10819.500	14059.500	-1.573	.116
		F	3.6733	.66941	300	194.44	58330.50				
		Total	3.6395	.69223	380						
	Post	M	3.8229	.73977	96	174.71	16772.00	12116.000	16772.000	-1.992	.046*
		F	3.9824	.52805	284	195.84	55618.00				
		Total	3.9421	.59178	380						
Personal relevance	Pre	M	3.8500	.83333	100	210.75	21074.50	16024.500	21074.500	-2.419	.016*
		F	4.0720	.79277	375	245.27	91975.50				
		Total	4.0253	.80570	475						
	Post	M	3.9750	.72717	120	206.94	24833.00	17573.000	24833.000	-3.291	.001**
		F	4.2310	.58960	355	248.50	88217.00				
		Total	4.1663	.63622	475						
Social relevance	Pre	M	4.0875	.78262	80	170.68	13654.00	10414.000	13654.000	-2.035	.042*
		F	4.2933	.64964	300	195.79	58736.00				
		Total	4.2500	.68387	380						
	Post	M	4.1667	.64346	96	175.00	16800.00	12144.000	16800.000	-1.823	.068
		F	4.3099	.58465	284	195.74	55590.00				
		Total	4.2737	.60241	380						
Interest	Pre	M	3.8500	.92524	100	210.19	21019.00	15969.000	21019.000	-2.489	.013*
		F	4.1067	.77689	375	245.42	92031.00				
		Total	4.0526	.81609	475						
	Post	M	3.9417	.62572	120	216.24	25949.00	18689.000	25949.000	-2.279	.023*
		F	4.1099	.65681	355	245.35	87101.00				
		Total	4.0674	.65256	475						
Total	Pre	M	3.7152	.91191	460	1013.30	466117.50	360087.500	466117.500	-3.302	.001**
		F	3.8858	.83169	1725	1114.25	1922087.50				
		Total	3.8499	.85184	2185						
	Post	M	3.8949	.74996	552	1002.28	553256.50	400628.500	553256.500	-4.396	.000***
		F	4.0686	.66804	1633	1123.67	1834948.50				
		Total	4.0247	.69359	2185						
2019											
Self-efficacy	Pre	M	3.4188	.95478	160	269.48	43117.00	23363.000	79643.000	-2.475	.013*
		F	3.2627	.78703	335	237.74	79643.00				
		Total	3.3131	.84708	495						
	Post	M	3.7103	.81579	145	259.94	37692.00	22918.000	82603.000	-1.583	.113
		F	3.6232	.77199	345	239.43	82603.00				
		Total	3.6490	.78538	490						

Note. M = Male; F = Female
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

However, the patterns of significant differences were varied for each component, as in the three cases as follows: differences absent in the pretest but present in the posttest; differences present in the pretest but absent in the posttest; differences present in both the pre- and posttest.

The first case corresponds to the Knowledge component, as presented in Table 2. Although the pretest score gap between male and female students was not significant, the results demonstrated that female students' scores improved somewhat more than those of male students after participation in the TPACK program.

The second case corresponded to the Social Relevance component. In the pretest, female participants tended to respond more positively than male students to questions about Social Relevance in convergence. On the other hand, this significant gap was reduced in the posttest. Although the results did not demonstrate dramatic changes in the *Z*-score and significance probability, the Year 1 results may indicate the contribution to improvements in the attitudes of the male group or the lack of effect to increase Social Relevance for the female group.

Another interpretation was drawn by contrasting Social Relevance against other components: Given that the scores of Social Relevance were the highest throughout the pre- and posttest, the scores themselves may have had effects. For example, when the initial score was high, there may have been factors of limitation on the extent of improvement, such as the means to indicate an even higher score.

Third, the components exhibiting differences in both the pretest and posttest were Personal Relevance and Interest, each of which also demonstrated differences in the overall scores of both the pre- and posttest. Regarding Personal Relevance and overall scores, the gender gap widened to a more significant level in the posttest, although a gap had already been present in the pretest results.

In both the Personal Relevance and the overall scores of the pre- and posttest, female students demonstrated more positive attitudes toward convergence. The components of Interest also revealed higher scores for female students in both the pre- and posttest, but the gender gap decreased relatively slightly, from $Z = -2.489$ to $Z = -2.279$, unlike in the case of personal relevance or overall scores.

Considering the Ertmer et al. (2007) study, which found that exemplary technology-using female teachers were highly concerned regarding personal beliefs, technology support, and access to hardware as a key factor of successfully integrated lessons, we infer that attitudes toward convergence of the female group are likely positive when a supportive teaching environment is prepared. In the past, society deemed and perceived technology as a male interest, so the perception may lead females to adopt negative attitudes toward technology tools (Ergen et al., 2019). However, several researchers noted that for positive attitudes, teacher training should provide activities that connect pedagogical content and specific instructional context, in sharing ideas with others, and in metareflecting on learning processes (Fazio et al., 2020; Hechter, 2011; Varol, 2015). In the research, it was determined that both female and male groups improved attitudes toward convergence in the TPACK training that included LATs planning activities, online and offline discussion, and the reflection of TPACK using Venn diagrams and rubrics.

The results of the test of attitudes toward convergence in the preservice teachers surveyed before and after the application of the TPACK program in Year 2 were analyzed by gender. No significant differences were found, with the exception of the Self-Efficacy component (Table 2). In marked contrast to the results of Year 1, where the effects of the gender-specific TPACK program were analyzed, the Year 2 results were not significantly different in components for which significant differences had been seen in Year 1. The only significant difference in year 2 was for the pretest of Self-Efficacy, which presented no significant difference in Year 1.

Above all, the absence of significant differences even in the other components of the pretest might indicate a unique characteristic of the group participating in the study, and the increase in the sample size of male students in Year 2 compared to Year 1 may have also had effects. This difference was possibly caused by the complexity of the construct that formed nonsingularly defined teacher attitudes (van Aalderen-Smeets et al., 2011).

In terms of methodology, scaling techniques are known for often being incapable of offering insights into learner progress. Nevertheless, past studies consistently have focused on the relationship between affective variables of beliefs, values, and attitudes and learner outcomes because of the role of attitude in advancing STEM education (Khine, 2015). Since affective structural bases of attitudes represent associations among emotions and beliefs, meta-attitudinal perspectives are important in measuring attitudes toward STEM subjects.

Similar to the earlier studies (Cheng & Xie, 2018; Sya'bandari et al., 2019), the current study may have also found that gender was significantly related to learner attitudes in convergence, but a few questions remain. The discussion by Sya'bandari et al. (2019) illustrated that female students had a higher interest in convergence than did males because of the difference in social sensitivity in collaborative works. They claimed that instructional designers should consider female learners’ low confidence in attitude toward convergence.

In this current study, however, female learners had generally high scores in the subcomponents of Knowledge, Personal Relevance, Social Relevance, Interest, and total score in Year 1, whereas male learners had higher Self-Efficacy in Year 2. A common feature was that the TPACK training intervention in a science method course changed the scores of attitudes toward convergence. We infer that gender-specific differences are not only determined by the gender variable, but also the contexts, as Renninger et al. (2018) mentioned. Therefore, the significant differences stand in multiple subcomponents in the result.

Li et al. (2016) argued that there was no significance difference between males and females in terms of attitude toward technology and perceived ease of technology use. They mentioned the possibility of preservice teachers’ concerns about the use of technology due to barriers they might encounter in practices. A college holds an important position with the ability to change the attitudes, beliefs, and values of intended teachers through teacher training (Poole & Isaacs, 1993). Therefore, it is essential that gender inequality in attitudes toward convergence is not produced in a way that affects scientific disciplines, skills, and STEM content knowledge.

Comparison by Gender Variables in Terms of TPACK

Appendix C presents the results comparing TPACK self-evaluation scores of preservice teachers participating in the TPACK program in Year 1 by gender using the Wilcoxon rank sum test. The components that proved to have significant gender-specific differences in the pre- or posttest were TK, CK of Science, CK of Literacy (Korean), PK, PCK, TCK, TPK, TPACK, and overall scores.

In the TPACK of the preservice teachers surveyed in Year 1, many components that demonstrated significant gender-specific differences in the pretest were improved in the posttest, including PK, PCK, TCK, TPK, TPACK, and overall scores. These results confirmed that the TPACK of female students who learned and experienced science teaching methods incorporating technology had effectively improved. Therefore, opportunities to combine preservice teachers’ perceptions of science and technology with classes must be affirmatively provided in science teacher education to prepare for integrated classes.

Appropriate teacher training using the TPACK framework may contribute to the enhancement of the expertise of preservice teachers (Erdogan & Sahin, 2010; Koh et al., 2015). Cheng and Xie (2018) insisted that gender could impact TPACK in a nonintervention setting, while teacher education and professional development programs boost the effects of the personal characteristics on TPACK. They mentioned that male teachers tend to have higher TK but lower PK than females. Socialization and gender expectation often play a significant role, because the attitudinal differences in technology could be distinct from the early aged learners. Similarly, the pretest results in Years 1 and 2, as shown in Tables 3 and 4, indicated that male preservice teachers have significantly higher scores for TK, but the TK of females leveled off after the intervention. This result indicated that perceived gender stereotypes that the preservice teachers were socialized with a long time ago were not permanent. For example, the findings by Cheng and Xie (2018) that female preservice teachers had significantly higher PK but lower TK than males can be reversed based on learning engagement.

A comparison of the gender-specific effects of the Year 2 TPACK program using the Wilcoxon rank sum test showed that the components elucidating significant differences were TK, CK of Mathematics, CK of Social studies, CK of Science, and TPACK, despite no gender-specific differences in overall scores (Appendix D).

TK, CK of Mathematics, and TPACK were the components that showed significant gender-specific differences in the pretest, with the gender gap diminishing in the posttest. In particular, the pretest scores for TK and CK of Mathematics were higher for male students enrolling in teachers college than for female students, consistent with previous research findings that male students were more confident in their technical or mathematical knowledge. This phenomenon affects the periods following employment, rendering it difficult for female teachers to acquire technological knowledge even if they are equipped with distinguished pedagogical knowledge (Chua & Jamil, 2014).

Based on the recent literature (Akyuz, 2018), we could consider TK as an independent factor for defining the TPACK of preservice teachers. The finding with the current study provides evidence that the gender of preservice teachers could be an indicator to predict a level of TK component, and it was hypothesized that existing cognitive TK could be predictable but not immutable. According to Erdogan and Sahin (2010), there are gender-specific differences in the TPACK of preservice mathematics teachers: men demonstrated higher TPACK competence than women and greater readily demonstrated knowledge links across various fields. They reported that male teacher candidates stated higher adequacies in the knowledge connection between the TPACK dimensions because of the statistically superior self-efficacy, whose criteria was based on perceived self-assessment, in a number of previous studies.

Despite similar performance levels, male students' self-evaluation of mathematics skills was higher than that of female students, and they have likewise been deemed highly motivated (Skaalvik & Rankin, 1994). Nonetheless, the results of this study indicate the potential for students to improve their confidence in technology or math regardless of gender through conscious TPACK training and experience. Therefore, even if male students were more confident in STEM subjects, gender differences may be debilitated by educational measures.

On the other hand, before and after the application of the TPACK program in this study, the components that did not see a reduction in the gender gap were CK of Social Studies and CK of Science. In social studies, male students at teachers' colleges scored higher in the pretest than female students, and the score discrepancy increased in the posttest. Knowledge in the science subject was associated with similar significance probabilities for both the pre- and posttest, revealing high scores for the male college student group. Unlike the results of this study, Mai and Hamzah (2016) asserted that there were no significant differences in any component when the science teachers were examined by the same test tool used by Schmidt et al. (2009) for TPACK investigations.

Comparison by Gender Variables in Terms of the Science Teaching Efficacy Beliefs

The gender-specific differences in the science teaching efficacy beliefs in Year 1 were analyzed using the Wilcoxon rank sum test. The results demonstrated that female students' scores were significantly higher overall and for PSTE in the post-test (Table 3).

Table 3
Results of the Wilcoxon Rank Sum Test on STEBI-B in 2018 to Compare Gender Variable

					Ranks			Test Statistics			
Component	Test	Gender	*M*	*SD*	*N*	Mean Rank	Sum of Ranks	Mann Whitney *U*	Wilcoxon *W*	*Z*	Asymp. Sig. (2-tailed)
PSTE	Pre	M	3.2308	.93856	260	597.46	155338.50	121408.500	155338.500	-1.112	.266
		F	3.3179	.86776	975	623.48	607891.50				
		Total	3.2996	.88346	1235						
	Post	M	3.1731	.99299	312	544.18	169784.50	120956.500	169784.500	-4.462	.000***
		F	3.4800	.94673	923	642.95	593445.50				
		Total	3.4024	.96746	1235						
Total	Pre	M	3.3522	.87441	460	1079.16	496415.50	390385.500	496415.500	-.566	.571
		F	3.3930	.86820	1725	1096.69	1891789.50				
		Total	3.3844	.86947	2185						
	Post	M	3.3207	.96419	552	997.04	550365.50	397737.500	550365.500	-4.420	.000***
		F	3.5511	.88975	1633	1125.44	1837839.50				
		Total	3.4929	.91441	2185						

Note. M = Male, F = Female
*** $p < .001$

This result differs from previous studies that asserted male teachers' self-efficacy and preservice teachers to be higher in terms of gender-specific differences. Some previous findings in STEBI indicated that male elementary school teachers tended to have stronger science teaching efficacy beliefs than those of female teachers and suggested that teacher education and research were necessary to bridge this gap (Kim, 2010; Park, 2002). Additionally, the study of self-efficacy in preservice teachers also indicates a tendency for lower science teaching efficacy belief in women, which is attributed to their experience as learners, tendency to ascribe success to external variables rather than personal abilities, and differences in gender-specific expectations (Bleicher, 2004; Riggs, 1991).

The results of this study in Year 1 implied that PSTE for women can be enhanced more effectively in teacher education programs addressing science education, contrary to the view that teaching efficacy is higher for men. This aspect was similar to the view of Yılmaz-Tüzün and Topçu (2013), who stated that senior female preservice teachers had highly positive beliefs and benefitted from their teacher education program regarding science teaching. A few personal variables, for instance, preservice teachers' perspectives on scientific knowledge, culture, gender role, and experience have been involved in affecting their self-efficacy (Kim & Jeong, 1996; Yılmaz-Tüzün & Topçu, 2013).

The findings in this study, however, proved that self-efficacy can be increased with a wide variety of experiences in a teaching method course of exploring educational technologies, understanding scientific concepts, applying proper pedagogical strategies for teaching contexts, and integrating knowledge. As Yuan et al. (2019) demonstrated, active participation in knowledge construction through problem-solving with technology issues may have the crucial role of enhancing preservice teachers' beliefs.

However, the results of Year 2 could not be seen as supporting the results of Year 1 in this study applying the TPACK theory. Comparing the STEBI-B pre- and posttest of the TPACK program application in Year 2 by gender, no significant gender-specific differences were found in the components of both PSTE and STOE, as well as overall scores. Results of the intergender statistics for the Year 2 STEBI-B overall scores were $Z = -.173$ for the pretest and $Z = -.044$ for the posttest. According to an analysis of the efficacy of science teaching among male and female participants in Year 2, gender variables were not powerful factors affecting STEBI-B scores because the scores of both groups improved from similar levels for each area. Without significant differences between the gender groups, the overall mean of PSTE rose from 3.2098 to 3.4969, the mean of STOE from 3.4222 to 3.5582, and the overall mean from 3.3022 to 3.5235.

A successful preservice teacher can teach a variety of students and maintain high confidence, which positively affects self-efficacy; therefore, the self-efficacy of teachers with shorter careers can be enhanced by an environment that enables successful experience (Yost, 2006). There are also views that courses related to technology integration as another factor for forecasting self-efficacy can provide positive reinforcement to improve self-efficacy for preservice teachers (Abbitt & Klett, 2004; Mason & Rich, 2019). In particular, Yuan et al. (2019) claimed that preservice teachers acquire knowledge regarding the way in which technologies are used in lesson practices through personally experienced strategies learned from meaningful and enjoyable struggles of overcoming difficulties in method courses. Though elementary teachers often have low self-confidence in STEM fields (Suters, 2021), opportunities for them to practice and reflect upon technological struggles to increase their TPACK would help enhance their self-efficacy (Mason & Rich, 2019).

Conclusions, Limitations, and Future Research

This study sought to analyze the effect of the TPACK program in terms of the gender of teachers college students, with regard to the effect of the TPACK approach in preservice teacher education as well as factors affecting the improvement of TPACK. During the autumn semesters of 2018 and 2019, quantitative data collected from tests before and after the application of the TPACK program were statistically analyzed using the Wilcoxon rank sum test to compare attitudes toward convergence, TPACK, and STEBI-B, based on group variables.

Comparisons by gender variables found that the components demonstrating significant differences according to the timing of implementation in Year 1 and 2 were either inconsistent or partially consistent. As for attitudes toward convergence, the components that showed significant differences before and after the TPACK programs in Year 1 and 2 were disparate. Gender-specific differences in Year 1 were revealed in the Knowledge, Personal Relevance, Social Relevance, Interest, and overall scores, while Year 2 results showed no such differences in most components.

Meanwhile, the pre- and posttest results of TPACK training showed significant gender-specific differences in Year 1 for TK, CK of Science, CK of Literacy (Korean), PK, PCK, TRK, TPACK, and overall scores and in Year 2 for TK, CK of Mathematics, CK of Social Studies, CK of Science, and TPACK. Among them, there were common gender-specific differences in the TK component in the pretest, but such differences were mitigated.

In this study, TPACK was effectively improved for female participant teachers who had learned and experienced science teaching methods incorporating technology. It was proved that a metacognitive inspection of TPACK could contribute to the professional development of preservice teachers. Thus, based on well-designed TPACK training and experience, teacher candidates may improve their confidence in science and technology regardless of gender. The analysis of STEBI-B by gender revealed that the overall scores and PSTE of the female group were high according to the comparison in Year 1, which was contrary to some previous studies that asserted that male in-service and preservice elementary school teachers demonstrated higher teaching efficacy. However, since there were no significant differences between genders in the STEBI-B pre- and posttest results in Year 2, further follow up research is needed to review whether gender variables are important factors affecting the STEBI-B test results.

The findings in this educational research have implications for the further research regarding gender variable issues in preservice teacher education, TPACK training, and professional development for teachers. We explored what meaning the gender issue has in the context of a science-content-based TPACK program application. It was confirmed that the preservice teacher education can mitigate existing differences of TPACK's subcomponents between gender groups and that the training can enhance the teaching efficacy of both male and female preservice teachers.

Being aware of insufficient skills and knowledge as an instructor, preservice teachers need to comprehend how they can properly organize science lessons and improve the technology-integrated learning environment. In order to reach this stage, they must be engaged in a metacognitive teaching experience so that they can be conscious of their own knowledge, beliefs, attitudes, and thoughts (Kozcu Çakir, 2020). Notably, since self-reflection on TPACK allows preservice teachers not only to adopt technologies in their classrooms but also to explore various methods for effective teaching in a content area (Chua & Jamil, 2014; Hofer & Grandgenett, 2012), we believe that metacognitive self-reflection in a TPACK program can be helpful those who have a lack of confidence on science teaching strategies.

Although we cannot conclusively conclude that one gender or the other may be categorically advantageous in TPACK development, it seems that a group that has comparatively weak TPACK on science teaching can improve attitudes or beliefs through preservice teacher education. As implied in previous studies (Ertmer et al., 2007; Jung, 2013; Zhang et al., 2019), this study concurs that preservice teachers' personal inner and psychological factors, in preference to gender, influence their TPACK and technology-integrated lesson plans. By supporting those factors, preservice teachers should be prepared to use technological resources effectively in science content-based classrooms.

Unlike perspectives finding that male preservice teachers had more familiarity with science and technology in some past studies (Erdogan & Sahin, 2010; Jo et al., 2000; Noh et al., 2013), this study focused on their development or change instead of that phenomenon itself explaining the gender difference, although we also considered the particularity of the gender-specific imbalance of the preservice teacher group. In view of the TPACK framework that explains the knowledge of teachers, epistemic development cannot be thought of separately from attitudes and self-efficacy. Although the gender variable might be a factor affecting preservice teachers before educational interventions, it is hard to see that the gender-specific influence continues even after they are involved in activities on TPACK self-reflection and integrated teaching methods.

Some limitations are associated with this study. First, the self-assessed type of survey data we collected in this study needs to be prudently interpreted because the findings cannot be generalized to different contexts of learning environment, targeted objective, and engaged preservice teachers' characteristics, such as age, nation, major, or grade. This quantitative study focused only on a science-based TPACK program designed for elementary preservice teachers. Second, the Likert scale instruments of attitudes toward convergence (Shin et al., 2014), TPACK (Schmidt et al., 2009), and science teaching efficacy beliefs (Enochs & Riggs, 1990) were adopted to investigate the internal scope of the participants that might be obscure to measure. To vigorously understand hidden factors of preservice teachers' attitudes, knowledge, and beliefs beyond their tendencies, other instruments and qualitative research approaches covering more specific dimensions may provide a more complete viewpoint.

Future research is needed to verify the effects of gender variables on self-efficacy in teacher preparation programs, which was expected to reveal the hypothesis in the current study due to a disagreement of two academic year results. It is also necessary to examine which factors are stable, the important attributes in preservice and in-service teachers' science teaching efficacy, and the improvement regarding their inner drive. Beyond gender, a study on the intrinsic and extrinsic factors, for instance, values, aspiration, openness, motivation, learning environment, administrative supports, opportunities for professional development, affecting attitudes, knowledge, and beliefs of preservice teachers may yield useful findings to prepare and implement educational programs for prospective teachers.

Last, since personal needs for success of integrated lessons may vary with the gender of teachers, more studies and policies on a supportive environment are needed to fulfill both female and male preservice and in-service teachers' expectations of the assistance.

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Appendix A

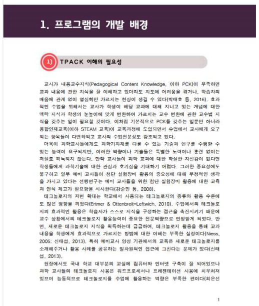
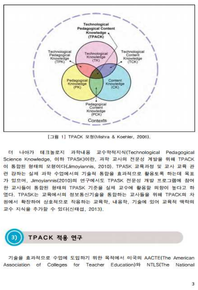
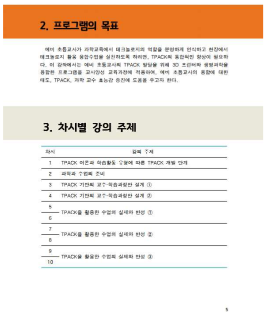
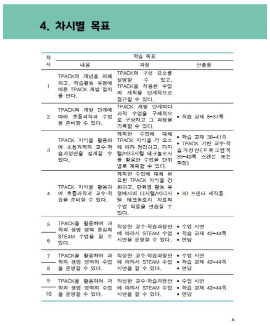
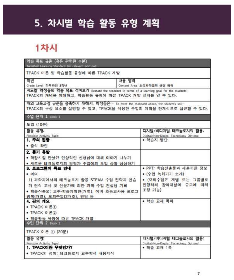
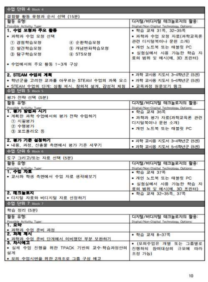
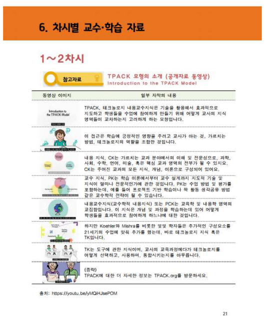
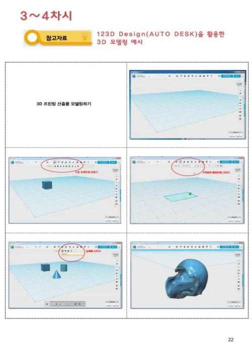
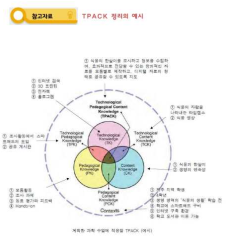
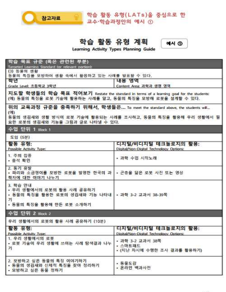
Course Outline and Sample Materials

Course outline, description and expectations for teaching science with reflection on TPACK

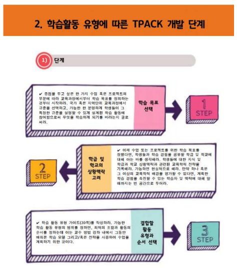
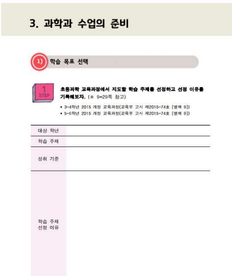
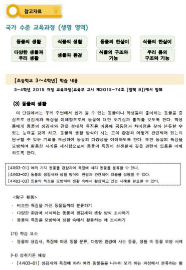
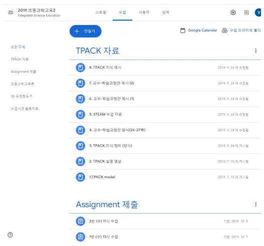
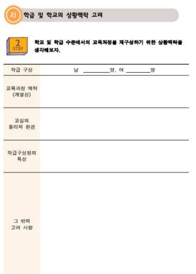
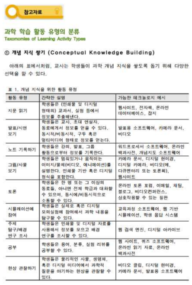
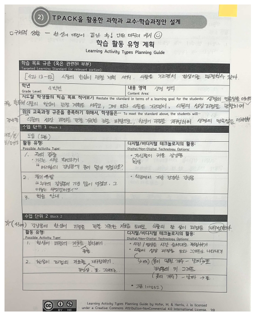
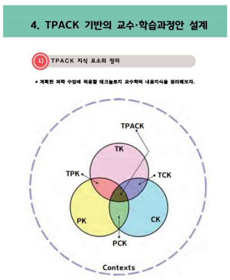
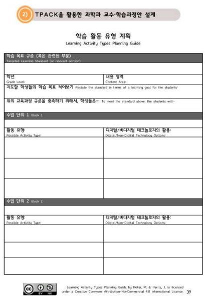
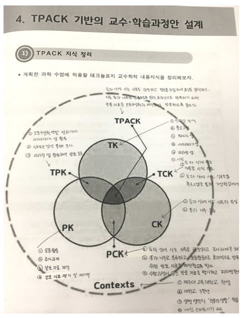
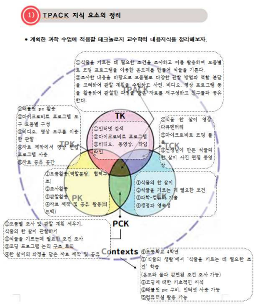
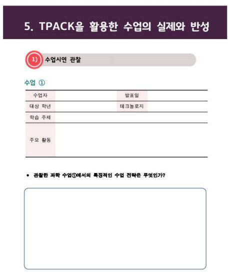
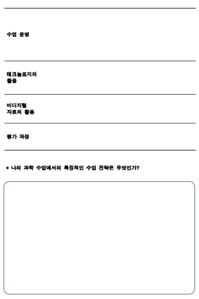
Week	Time (Hours)	Lesson topic	Description of activities	Expectations		Content area
				Content	Outcomes	
1	2	1. The theory and the procedure of TPACK framework based on learning activity types	Teacher candidates learn the components of the TPACK framework and discuss the lesson planning phase based on TPACK.	Teacher candidates understand the ideas of the TPACK framework and the procedure of TPACK development based on learning activity types.		Pedagogy
2-3	4	2. Organization of the science content-based STEM lessons	In each stage, teacher candidates detail their plans for mock lessons and write down the process of lesson planning.	Teacher candidates organize science content-based STEM lessons at the elementary school level using the TPACK development procedure.	• Lesson planning with the following stages: - determine targeted learning standards and goals - consider the classroom and school contexts - choose learning activity types and sequence - make an assessment plan - select learning materials and aids	Life Science or Earth Science
4	2	3. Lesson plan design based on the TPACK framework	Teacher candidates make an individual lesson plan for an integrated science lesson using their TPACK. They also include digital and nondigital options for each lesson block of learning activity types.	Teacher candidates review their TPACK and its constituents for the planned lessons.	• A Venn diagram for TPACK review • Learning activity type planning	Life Science or Earth Science
5	2	4. Preparation for STEM lessons using the TPACK framework	Teacher candidates experience the importance of TPACK for their planned lessons. They also rehearse applications of digital and nondigital materials according to the learning activity types.	Teacher candidates prepare for integrated science lessons using their TPACK.	• A science content-based STEM lesson plan with TPACK • Digital or nondigital tools and resources for learning activity types	Life Science or Earth Science
6-8	6	5. Practice and reflection on teaching with TPACK	Teacher candidates demonstrate their integrated lessons according to the plan.	Teacher candidates implement the integrated science content-based lessons applying their TPACK.	• Teaching demonstrations • Lesson observations • Reflective assessment	Life Science or Earth Science

Sample Materials and Learner Outcomes

Instructors Guidebook

Contents	Examples		Features
Background literature on program development			• Introduction • Literatures • Definition of TPACK • TPACK framework and its components (video) • Impact of technology in integrated lessons • Studies on TPACK development
Objectives, lesson topics, and course overview			• Goal and objectives • Periods and lesson topics • Outline and overview of the program • Expectations in terms of content, process, and outcome
Plans of learning activity types (8 periods)			• Each plan includes targeted learning standards, learning goals, detailed expectations, learning blocks, time, possible activity types, digital/non-digital options, resources (e.g., links, movies, pictures, and software etc.), and considerations.
Program resources			• Information of digital resources (e.g., video, 3D modeling, digital archive, learning management systems, social media, time-lapse, links, digital documents, etc.) • References
Examples of possible learner outcomes			• Components of TPACK and its Venn diagram • Samples of learning activity types planning guide with contents from the 2015 revised national science curriculum in Korea

Preservice Teachers Workbook

Contents	Examples	Features or sample outcomes
The theory and the procedure of the TPACK framework based on learning activity types	 	• TPACK theory and discussion • Introduction on a flexible five-step process (Hofer & Harris, 2015): ① Choose learning goals, ② Consider classroom and school contexts, ③ Select activity types to combine and sequence, ④ Select assessment strategies, ⑤ Select tools and/or resources
Organization of the science content-based STEM lessons	 	• The 2015 revised national science curriculum standards in Korea • Disciplines and steps for an integrated lesson • Assessment standards, method, and moments • Digital/non-digital resources 
Lesson plan design based on the TPACK framework	 	• The science taxonomy LATs categories as conceptual knowledge building, procedural knowledge building, and knowledge expression (Hofer & Harris, 2015) 
Preparation for STEM lessons using the TPACK framework	 	 
Practice and reflection on teaching with TPACK	 	• Teaching demonstrations of the preservice teachers' learning activity types planning which designed by their TPACK (e.g., planetarium software application Sky Map, storytelling, problem-solving activities, and stars and constellations in the pictures) • Discussion about teaching and learning of both colleagues and themselves.  

Appendix B
Survey of Preservice Teachers' Attitude Toward Convergence, TPACK, and Science Teaching Efficacy Belief

Attitude Toward Convergence

Attitude Toward Convergence (Shin et al., 2014)

1. 융합에 대한 태도

class	학급	______학년 ______반	성별 gender	□ 여자 (female) □ 남자 (male)
major	심화전공	____________________전공	출신고교계열	□ 인문 □ 자연 □ 기타

※ 다음은 '융합에 대한 태도'를 알아보기 위한 질문입니다. 검사의 결과는 여러분의 성적과는 아무 관련이 없으며 그 결과 또한 공개하지 않습니다.
각 문항마다 매우 아니다, 아니다, 보통이다, 그렇다, 매우 그렇다 중에 ✓ **표시해 주십시오.**

번호	문항 questions	매우 아니다 (strongly disagree)	아니다 (disagress)	보통이다 (neutral)	그렇다 (agree)	매우 그렇다 (strongly agree)
1	융합이 무엇을 뜻하는지 다른 사람에게 설명할 수 있다.					
2	융합의 사례를 말할 수 있다.					
3	융합학문과 다른 학문의 차이점을 말할 수 있다.					
4	융합이 일상생활에서 활용된 경우를 말할 수 있다.					
5	융합은 내가 공부하는 내용들과 관련이 있다.					
6	융합을 잘 하는 것은 내가 공부하는데 도움이 된다.					
7	융합은 미래의 나의 생활과 관련이 있을 것이다.					
8	융합은 내가 궁금증과 흥미를 가지고 있는 주변의 일들을 이해하는데 도움을 준다.					
9	융합은 내가 일상생활에서 겪게 되는 복잡한 문제들을 해결하는데 도움을 줄 것이다.					
10	융합은 현대사회의 복잡한 문제를 해결하는데 도움이 될 것이다.					
11	융합은 앞으로 사회가 발전해 나가는데 도움을 줄 것이다.					
12	융합은 현대문명과 사회를 이해하는데 도움을 줄 것이다.					
13	융합은 21세기 미래사회를 준비하는데 도움을 줄 것이다.					
14	한 분야의 지식과 다른 분야의 지식과의 연관성을 찾는 것은 재미있다.					
15	내가 관심 있는 주제와 관련된 다양한 분야의 지식을 알아가는 과정이 즐겁다.					
16	서로 다른 생각을 가진 사람들과 함께 아이디어를 만들어 내는 과정에 참여하는 것은 재미있다.					
17	다양한 분야의 전문가들이 협력을 통하여 문제를 해결한 사례는 흥미롭다.					
18	한 분야에서의 경험, 아이디어를 다른 분야에 창의적으로 접목시킨 사람들의 경험담은 흥미롭다.					
19	나는 한 분야의 지식과 다른 분야의 지식과의 연관성을 찾는 것을 잘한다.					
20	나는 관심 있는 주제와 관련된 다양한 분야의 지식을 알아가는 것을 잘한다.					
21	나는 다양한 분야의 지식을 활용하여 문제를 해결하는 것을 잘한다.					
22	나는 평소 한 가지 문제를 다방면으로 보는데 능숙하다.					
23	나는 문제를 해결하려 할 때 다양한 분야의 지식을 활용하는 것을 잘한다.					

Knowledge
1. I can explain what convergence means.
2. I know examples of convergence.
3. I know the difference between integrated discipline and others.
4. I know how the integration works in daily life.

Personal relevance
5. Convergence is relevant to the contents I study.
6. Convergence is helpful to my studying.
7. Convergence will be connected with my future.
8. Convergence helps to understand phenomena that I am curious about and interested in.
9. Convergence will help to solve complicated problems in daily life.

Social relevance
10. Convergence will help to solve complicated problems in society.
11. Convergence will contribute to social development.
12. Convergence will let us understand modern civilization and society.
13. Convergence will help to prepare the 21st future society.

Interest
14. It is interesting to find the relation between a field of knowledge and it from other fields.
15. I am pleased when I know various knowledge that connected my interest.
16. It is interesting to join a process to create a collaborative idea with colleagues having different ideas.
17. It is interesting successful cases that solve a problem through collaborative works by experts from various fields.
18. It is interesting stories that people creatively connect an experience or idea to other fields.

Self-efficacy
19. I can find relation between my knowledge and other disciplines.
20. I acquire various fields of knowledge that are related to my interest.
21. I solve a problem using more than one field of knowledge.
22. I am proficient in looking at one problem from several perspectives.
23. I am competent in using cross-disciplinary knowledge when I solve a problem.

Technological Pedagogical Content Knowledge

Technological Pedagogical Content Knowledge (Schmidt et al., 2009)

2. 테크놀로지 내용교수지식(TPACK)

class **학급**	_____학년 _____반	**성별** gender	□ 여자 female □ 남자 male	
major **심화전공**	______________전공	**출신고교계열**	□ 인문 □ 자연 □ 기타	

※ 다음은 '테크놀로지 내용교수지식'을 알아보기 위한 질문입니다. 검사의 결과는 여러분의 성적과는 아무 관련이 없으며 그 결과 또한 공개하지 않습니다.
각 문항마다 전혀 그렇지 않다, 그렇지 않다, 보통이다, 그렇다, 매우 그렇다 중에 √ **표시해 주십시오.**

번호	문항 questions	전혀 그렇지 않다 strongly disagree	그렇지 않다 disagress	보통이다 neither agree/ disagree	그렇다 agree	매우 그렇다 strongly agree
	테크놀로지 지식(TK)					
1	나는 테크놀로지를 사용하다가 문제가 생길 경우 스스로 해결할 수 있다.					
2	나는 테크놀로지를 쉽게 배울 수 있다.					
3	나는 중요한 새 테크놀로지가 나올 때마다 적응할 수 있다.					
4	나는 테크놀로지를 자주 사용한다.					
5	나는 다양한 테크놀로지를 알고 있다.					
6	나는 테크놀로지를 사용할 수 있는 공학적 기술이 있다.					
7	나는 다양한 테크놀로지를 사용한 경험이 풍부하다.					
	내용지식(CK)-수학					
8	나는 수학교과에 대한 지식이 풍부하다.					
9	나는 수학적 사고를 할 수 있다.					
10	나는 수학교과를 이해하는 데 도움이 되는 다양한 학습전략을 가지고 있다.					
	내용지식(CK)-사회					
11	나는 사회교과에 대한 지식이 풍부하다.					
12	나는 사회교과적 사고(예: 역사적 접근)를 할 수 있다.					
13	나는 사회교과를 이해하는 데 도움이 되는 다양한 학습전략을 가지고 있다.					
	내용지식(CK)-과학					
14	나는 과학교과에 대한 지식이 풍부하다.					
15	나는 과학적 사고를 할 수 있다.					
16	나는 과학교과를 이해하는 데 도움이 되는 다양한 학습전략을 가지고 있다.					
	내용지식(CK)-국어					
17	나는 국어교과에 대한 지식이 풍부하다.					
18	나는 국어교과적 사고(예: 문해능력)를 할 수 있다.					
19	나는 국어교과를 이해하는 데 도움이 되는 다양한 학습전략을 가지고 있다.					
	교수지식(PK)					
20	나는 수업상황에서 학생의 수행수준을 평가하는 방법을 알고 있다.					
21	나는 학생들이 이해 또는 이해하지 못하는 것이 무엇인지에 따라 교수법을 바꿀 수 있다.					
22	나는 학생의 수준에 맞추어 내 교수방식을 바꿀 수 있다.					

TK
1. I know how to solve my own technical problems.
2. I can learn technology easily.
3. I keep up with important new technologies.
4. I frequently play around with the technology.
5. I now about a lot of different technologies.
6. I have the technical skills I need to use technology.
7. I have had sufficient opportunities to work with different technologies.

CK-Mathematics
8. I have sufficient knowledge about mathematics.
9. I can use a mathematical way of thinking.
10. I have various ways and strategies of developing my understanding of mathematics.

CK-Social Studies
11. I have sufficient knowledge about social studies.
12. I can use historical way of thinking.
13. I have various way and strategies of developing my understanding of social studies.

CK-Science
14. I have sufficient knowledge about science.
15. I can use a scientific way of thinking.
16. I have various ways and strategies of developing my understanding of science.

CK-Literacy
17. I have sufficient knowledge about literacy.
18. I can use a literary way of thinking.
19. I have various ways and strategies of developing my understanding of literacy.

PK
20. I know how to assess student performance in a classroom.
21. I can adapt my teaching based upon what students currently understand or do not understand.
22. I can adapt my teaching style to different learners.

(continued)

23	나는 학생의 학습수준을 다양한 방식을 통해 측정할 수 있다.
24	나는 수업상황에서 다양한 교수법을 사용할 수 있다.
25	나는 학생들이 일반적으로 보이는 잘못된 이해 또는 오개념들을 잘 알고 있다.
26	나는 교실 관리 및 운영을 할 수 있다.
	내용교수지식(PCK)
27	나는 수학교과에서 학생들의 사고와 학습을 촉진할 수 있는 효과적인 교수법을 선택할 수 있다.
28	나는 사회교과에서 학생들의 사고와 학습을 촉진할 수 있는 효과적인 교수법을 선택할 수 있다.
29	나는 과학교과에서 학생들의 사고와 학습을 촉진할 수 있는 효과적인 교수법을 선택할 수 있다.
30	나는 국어교과에서 학생들의 사고와 학습을 촉진할 수 있는 효과적인 교수법을 선택할 수 있다.
	테크놀로지 내용지식(TCK)
31	나는 수학교과에서 이해를 돕기 위해 사용할 수 있는 여러 가지 테크놀로지를 알고 있다.
32	나는 사회교과에서 이해를 돕기 위해 사용할 수 있는 여러 가지 테크놀로지를 알고 있다.
33	나는 과학교과에서 이해를 돕기 위해 사용할 수 있는 여러 가지 테크놀로지를 알고 있다.
34	나는 국어교과에서 이해를 돕기 위해 사용할 수 있는 여러 가지 테크놀로지를 알고 있다.
	테크놀로지 교수지식(TPK)
35	나는 교수법의 효과를 증진시킬 수 있는 테크놀로지를 선택할 수 있다.
36	나는 학생들의 학습을 촉진시킬 수 있는 테크놀로지를 선택할 수 있다.
37	교직수업을 통해 테크놀로지가 내 교수법에 미치는 영향에 대해서 생각해본 적이 있다.
38	나는 테크놀로지를 수업에 어떻게 활용할 것인지 비판적으로 생각해본다.
39	내가 현재 배우고 있는 테크놀로지를 수업의 다양한 활동에 적용할 수 있다.
	테크놀로지 내용교수지식(TPACK)
40	나는 내 수업에서 수학교과, 테크놀로지, 교수법을 적절하게 통합하여 가르칠 수 있다.
41	나는 내 수업에서 사회교과, 테크놀로지, 교수법을 적절하게 통합하여 가르칠 수 있다.
42	나는 내 수업에서 과학교과, 테크놀로지, 교수법을 적절하게 통합하여 가르칠 수 있다.
43	나는 내 수업에서 국어교과, 테크놀로지, 교수법을 적절하게 통합하여 가르칠 수 있다.
44	나는 내가 가르치는 교과, 교수법, 그리고 학생들이 학습하는 내용을 촉진할 수 있는 테크놀로지를 선택할 수 있다.
45	나는 교직과정을 통해 배운 교과, 테크놀로지, 교수법을 통합한 전략을 수업에서 사용할 수 있다.
46	나는 동료들이 교과, 테크놀로지, 교수법을 적절히 통합하여 활용할 수 있도록 도와주는 리더십을 발휘할 수 있다.
47	나는 수업내용의 학습을 촉진하는 테크놀로지를 사용할 수 있다.

23. I can assess student learning in multiple ways.
24. I can use a wide range of teaching approaches in a classroom setting.
25. I am familiar with common student understandings and misconceptions.
26. I know how to organize and maintain classroom management.

PCK

27. I can select effective teaching approaches to guide student thinking and learning in mathematics.
28. I can select effective teaching approaches to guide student thinking and learning in literacy.
29. I can select effective teaching approaches to guide student thinking and learning in science.
30. I can select effective teaching approaches to guide student thinking and learning in social studies.

TCK

31. I know about technologies that I can use for understanding and doing mathematics.
32. I know about technologies that I can use for understanding and doing literacy.
33. I know about technologies that I can use for understanding and doing science.
34. I know about technologies that I can use for understanding and doing social studies.

TPK

35. I can choose technologies that enhance the teaching approaches for a lesson.
36. I can choose technologies that enhance students' learning for a lesson.
37. My teacher education program has caused me to think more deeply about how technology could influence the teaching approaches I use in my classroom.
38. I am thinking critically about how to use technology in my classroom.
39. I can adapt the use of the technologies that I am learning about to different teaching activities.

TPACK

40. I can teach lessons that appropriately combine mathematics, technologies, and teaching approaches.
41. I can teach lessons that appropriately combine literacy, technologies, and teaching approaches.
42. I can teach lessons that appropriately combine science, technologies, and teaching approaches.
43. I can teach lessons that appropriately combine social studies, technologies, and teaching approaches.
44. I can select technologies to use in my classroom that enhance what I teach, how I teach, and what students learn.
45. I can use strategies that combine content, technologies, and teaching approaches that I learned about in my coursework in my classroom.
46. I can provide leadership in helping others to coordinate the use of content, technologies, and teaching approaches at my school and/or district.
47. I can choose technologies that enhance the content for a lesson.

Science Teaching Efficacy Belief Instrument B

Science Teaching Efficacy Belief Instrument B (Enochs & Riggs, 1990)

3. 과학 교수 효능감

class	학급	______학년 ______반	성별 gender	□ 여자 (female) □ 남자 (male)
major	심화전공	____________________전공	출신고교계열	□ 인문 □ 자연 □ 기타

※ 다음은 '과학 교수 효능감'을 알아보기 위한 질문입니다. 검사의 결과는 여러분의 성적과는 아무 관련이 없으며 그 결과 또한 공개하지 않습니다.
각 문항마다 전혀 그렇지 않다, 그렇지 않다, 보통이다, 그렇다, 매우 그렇다 중에 √ **표시해 주십시오.**

번호	문항 questions	전혀 그렇지 않다 strongly disagree	그렇지 않다 disagress	보통이다 uncertain	그렇다 agree	매우 그렇다 strongly agree
1	과학 교과에서 학생이 평소보다 잘할 때는, 교사의 추가적인 노력이 있었기 때문이다.					
2	나는 과학을 가르치는 더 나은 방법을 꾸준히 찾을 것이다.					
3	내가 열심히 노력하더라도, 대부분의 교과를 지도하는 것처럼 과학을 지도할 수 없다.					
4	학생의 과학 점수가 향상된다면, 교사가 효과적인 수업 방법을 찾았기 때문이다.					
5	나는 과학 개념을 효과적으로 지도하기 위해 필요한 절차를 안다.					
6	나는 과학 실험을 효과적으로 모니터링 할 수 없다.					
7	만약 학생들이 과학에서 자기 능력 이하의 성적을 내고 있다면, 효과적이지 못한 과학 수업 때문인 것 같다.					
8	나는 대개 과학을 비효율적으로 지도한다.					
9	학생의 과학 배경지식이 부족함은 훌륭한 수업으로 극복할 수 있다.					
10	일부 학생들의 낮은 과학성취도에 대해 일반적으로 교사 탓을 할 수 없다.					
11	학생의 낮은 과학성취도가 향상되었으면, 대개는 교사가 추가적으로 관심을 기울였기 때문이다.					
12	나는 초등과학을 효과적으로 지도하기 위한 과학 개념을 충분히 잘 이해하고 있다.					
13	과학 지도에 있어 더 노력을 하더라도 몇몇 학생들의 과학성취도는 변화가 미미하다.					
14	일반적으로 과학에서 교사가 학생들의 성취도에 대한 책임이 있다.					
15	학생들의 과학성취도는 교사의 노력과 직접적으로 연관이 있다.					
16	부모들이 자녀가 학교에서 과학에 많은 흥미를 보인다고 말한다면, 아마도 선생님이 잘한 덕분이다.					
17	나는 학생들에게 과학 실험에서 왜 효과가 있었는지를 설명하는데 어려움을 느낄 것이다.					
18	나는 늘 그렇듯이 학생들의 과학 질문에 대답할 수 있을 것이다.					
19	내가 과학을 지도하는데 필요한 기술을 익힐 수 있을지 궁금하다.					
20	선택할 수 있다면, 내 과학 수업을 평가하려는 교장이 참관하는 수업을 하지 않을 것이다.					
21	학생이 과학 개념을 이해하는데 어려움을 겪을 때, 어떻게 그 학생이 더 잘 이해하도록 도와주어야 할지 모르겠다.					
22	과학을 가르칠 때, 나는 학생들의 질문을 반긴다.					
23	나는 학생들이 과학에 흥미를 갖게 하는 방법을 모른다.					

1. When a student does better than usual in science, it is often because the teacher exerted a little extra effort.
2. I will continually find better ways to teach science.
3. Even if I try very hard, I will not teach science as well as I will most subjects.
4. When the science grades of students improve, it is often due to their teacher having found a more effective teaching approach.
5. I know the steps necessary to teach science concepts effectively.
6. I will not be very effective in monitoring science experiments.
7. If student are underachieving in science teaching.
8. I will generally teach science ineffectively.
9. The inadequacy of a student's science background can be overcome by good teaching.
10. The low science achievement of some students cannot generally be blamed on their teachers.
11. When a low-achieving child progresses in science, it is usually due to extra attention given by the teacher.
12. I understand science concepts well enough to be effective in teaching elementary science.
13. Increased effort in science teaching produces little change in some students' science achievement.
14. The teacher is generally responsible for the achievement of students in science.
15. Students' achievement in science is directly related to their teacher's effectiveness in science teaching.
16. If parents comment that their child is showing more interest in science at school, it is probably due to the performance of the child's teacher.
17. I will find it difficult to explain to students why science experiments work.
18. I will typically be able to answer students' science questions.
19. I wonder if I will have the necessary skills to teach science.
20. Given a choice, I will not invite the principal to evaluate my science teaching.
21. When a student has difficulty understanding a science concept, I will usually be at a loss as to how to help the student understand it better.
22. When teaching science, I will usually welcome student questions.
23. I do not know what to do to turn students on to science.

Appendix C
Results of the Wilcoxon Rank Sum Test on TPACK in 2018 to Compare the Gender Variable

Component	Test	Gender	*M*	*SD*	Ranks *N*	Ranks Mean Rank	Ranks Sum of Ranks	Test Statistics Mann Whitney *U*	Test Statistics Wilcoxon *W*	Test Statistics *Z*	Test Statistics Asymp. Sig. (2-tailed)
TK	Pre	M	3.0000	.95209	140	380.16	53223.00	30147.000	168222.000	-3.435	.001 *
		F	2.6876	.92955	525	320.42	168222.00				
		Total	2.7534	.94228	665						
	Post	M	3.6250	.87334	168	351.98	59132.00	38560.000	162313.000	-1.600	.110
		F	3.5332	.85631	497	326.59	162313.00				
		Total	3.5564	.86091	665						
CK of Science	Pre	M	3.2833	.97584	60	188.37	11302.00	4028.000	29453.000	-5.050	.000***
		F	2.6000	.87117	225	130.90	29453.00				
		Total	2.7439	.93504	285						
	Post	M	3.5000	.85580	72	153.92	11082.50	6881.500	29672.500	-1.395	.163
		F	3.3803	.80739	213	139.31	29672.50				
		Total	3.4105	.82001	285						
CK of Literacy (Korean)	Pre	M	3.3667	1.02456	60	123.01	7380.50	5550.500	7380.500	-2.237	.025*
		F	3.7022	.89903	225	148.33	33374.50				
		Total	3.6316	.93507	285						
	Post	M	3.4444	.78523	72	121.26	8730.50	6102.500	8730.500	-2.806	.005**
		F	3.7793	.77286	213	150.35	32024.50				
		Total	3.6947	.78821	285						
PK	Pre	M	3.3286	.95543	140	311.06	43549.00	33679.000	43549.000	-1.640	.101
		F	3.5200	1.53275	525	338.85	177896.00				
		Total	3.4797	1.43219	665						
	Post	M	3.6131	.78858	168	298.06	50073.50	35877.500	50073.500	-3.034	.002**
		F	3.8149	.71416	497	344.81	171371.50				
		Total	3.7639	.73830	665						
PCK	Pre	M	3.3625	.88937	80	191.85	15348.00	11892.000	57042.000	-.134	.893
		F	3.3433	.80058	300	190.14	57042.00				
		Total	3.3474	.81889	380						
	Post	M	3.4167	.70587	96	146.05	14020.50	9364.500	14020.500	-5.051	.000***
		F	3.8380	.74850	284	205.53	58369.50				
		Total	3.7316	.75950	380						
TCK	Pre	M	2.8625	.88223	80	198.74	15899.00	11261.000	56111.000	-.850	.395
		F	2.7826	.93204	299	187.66	56111.00				
		Total	2.7995	.92118	379						
	Post	M	3.4063	.76197	96	166.47	15981.00	11325.000	15981.000	-2.700	.007**

Component	Test	Gender	*M*	*SD*	Ranks			Test Statistics			
					N	Mean Rank	Sum of Ranks	Mann Whitney *U*	Wilcoxon *W*	*Z*	Asymp. Sig. (2-tailed)
		F	3.6761	.79352	284	198.62	56409.00				
		Total	3.6079	.79340	380						
TPK	Pre	M	3.0300	.84632	100	236.52	23651.50	18601.500	23651.500	-.128	.898
		F	3.0080	.90598	375	238.40	89398.50				
		Total	3.0126	.89292	475						
	Post	M	3.6167	.73546	120	194.34	23321.00	16061.000	23321.000	-4.673	$.000^{***}$
		F	3.9577	.63860	355	252.76	89729.00				
		Total	3.8716	.67998	475						
TPACK	Pre	M	3.0250	.79265	160	358.10	57296.50	44416.500	57296.500	-1.552	.121
		F	3.0967	.84173	600	386.47	231883.50				
		Total	3.0816	.83164	760						
	Post	M	3.5313	.70826	192	314.17	60321.00	41793.000	60321.000	-5.302	$.000^{***}$
		F	3.8451	.69815	568	402.92	228859.00				
		Total	3.7658	.71342	760						
Total	Pre	M	3.1468	.93434	940	2274.69	2138209.50	1616620.500	7827670.500	-1.187	.235
		F	3.0993	1.07050	3524	2221.25	7827670.50				
		Total	3.1093	1.04338	4464						
	Post	M	3.5213	.79343	1128	2020.69	2279337.00	1642581.000	2279337.000	-6.991	$.000^{***}$
		F	3.7156	.77412	3337	2304.77	7691008.00				
		Total	3.6665	.78352	4465						

Note. M = Male, F = Female
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Appendix D
Results of the Wilcoxon Rank Sum Test on TPACK in 2019 to Compare the Gender Variable

					Ranks			Test Statistics			
Component	Test	Gender	*M*	*SD*	*N*	Mean Rank	Sum of Ranks	Mann Whitney *U*	Wilcoxon *W*	*Z*	Asymp. Sig. (2-tailed)
TK	Pre	M	2.9063	1.02662	224	387.60	86823.00	43433.000	153648.000	-3.890	.000***
		F	2.5991	.86558	469	327.61	153648.00				
		Total	2.6984	.93113	693						
	Post	M	3.5517	1.02495	203	356.26	72320.50	46434.500	163320.500	-1.154	.248
		F	3.4658	.89511	483	338.14	163320.50				
		Total	3.4913	.93547	686						
CK of Math	Pre	M	3.4583	.84501	96	171.84	16497.00	7455.000	27756.000	-3.361	.001**
		F	3.0846	.88194	201	138.09	27756.00				
		Total	3.2054	.88621	297						
	Post	M	3.5402	.84640	87	153.51	13355.00	8482.000	30010.000	-.842	.400
		F	3.4686	.80516	207	144.98	30010.00				
		Total	3.4898	.81678	294						
CK of Social Studies	Pre	M	3.4063	.90121	96	163.67	15712.00	8240.000	28541.000	-2.170	.030*
		F	3.1692	.82537	201	142.00	28541.00				
		Total	3.2458	.85633	297						
	Post	M	3.7126	.90101	87	168.78	14684.00	7153.000	28681.000	-2.970	.003**
		F	3.3816	.79088	207	138.56	28681.00				
		Total	3.4796	.83723	294						
CK of Science	Pre	M	2.9479	.87503	96	163.76	15721.00	8231.000	28532.000	-2.179	.029*
		F	2.7512	.82329	201	141.95	28532.00				
		Total	2.8148	.84393	297						
	Post	M	3.5287	.79004	87	162.85	14168.00	7669.000	29197.000	-2.183	.029*
		F	3.3575	.78067	207	141.05	29197.00				
		Total	3.4082	.78601	294						

Component	Test	Gender	*M*	*SD*	Ranks			Test Statistics			
					N	**Mean Rank**	**Sum of Ranks**	**Mann Whitney *U***	**Wilcoxon *W***	***Z***	**Asymp. Sig. (2-tailed)**
TPACK	Pre	M	2.7891	1.06386	256	368.61	94363.50	61467.500	94363.500	-2.537	.011**
		F	3.0560	.75172	536	409.82	219664.50				
		Total	2.9697	.87331	792						
	Post	M	3.5991	.74357	232	372.09	86325.50	59297.500	86325.500	-1.808	.071
		F	3.7101	.69693	552	401.08	221394.50				
		Total	3.6773	.71238	784						

Note. M = Male, F = Female
$^{*}p<.05$, $^{**}p<.01$, $^{***}p<.001$